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MODELLING THE SEA KING HELICOPTER IN THE INTEGRATED PERFORMANCE MODELLING ENVIRONMENT (IPME)

by:

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14. ABSTRACT

U) Defence Research and Development Canada (DRDC) Toronto contracted Humansystems Incorporated® (Humansystems®; HSIâ) to conduct a hierarchical goal analysis and construct a human performance model of pilot activities associated with the Sea King helicopter. In particular, DRDC Toronto wanted the human performance model to include activities surrounding Helicopter Deck Landing (HDL) aboard a Navy ship. Ultimately, this model would be used to control a simulated Sea King helicopter. The human performance modelling application used for this project was the Integrated Performance Modelling Environment (IPME). This report describes the output from the goal analysis, the mission used to 'bound' the IPME modelling efforts, the data used to populate the IPME model, assumptions and approach used in the modelling effort, conclusions, and recommendations for follow-on work. With respect to the follow-on work, some suggestions are made regarding areas to focus on and approach to take. The IPME model of Sea King helicopter pilots forms a separate deliverable under this contract.

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Abstract

Defence Research and Development Canada (DRDC) Toronto contracted Human*systems* Incorporated® (Human*systems*®; HSI®) to conduct a hierarchical goal analysis and construct a human performance model of pilot activities associated with the Sea King helicopter. In particular, DRDC Toronto wanted the human performance model to include activities surrounding Helicopter Deck Landing (HDL) aboard a Navy ship. Ultimately, this model would be used to control a simulated Sea King helicopter. The human performance modelling application used for this project was the Integrated Performance Modelling Environment (IPME).

This report describes the output from the goal analysis, the mission used to 'bound' the IPME modelling efforts, the data used to populate the IPME model, assumptions and approach used in the modelling effort, conclusions, and recommendations for follow-on work. With respect to the follow-on work, some suggestions are made regarding areas to focus on and approach to take. The IPME model of Sea King helicopter pilots forms a separate deliverable under this contract.

Résumé

Recherche et développement pour la défense Canada (RDDC) Toronto a attribué un contrat à Humansystems Incorporated (HSI) pour effectuer une analyse hiérarchique d'objectifs et construire un modèle de performance humaine pour les activités des pilotes liées à l'hélicoptère *Sea King*. Plus particulièrement, RDDC Toronto voulait que le modèle de performance humaine comprenne les activités entourant l'atterrissage sur une héliplate-forme à bord d'un navire de la Marine. En bout de ligne, ce modèle servirait à contrôler un hélicoptère *Sea King* simulé. L'application de modélisation de la performance humaine utilisée pour ce projet était l'environnement intégré de modélisation de la performance (IPME).

Le présent rapport décrit le résultat de l'analyse d'objectifs, la mission utilisée pour « limiter » le travail de modélisation de l'IPME, les données ayant servi à charger le modèle de l'IPME, les hypothèses et la démarche utilisées dans le travail de modélisation, les conclusions et les recommandations pour le suivi. Relativement à ce dernier, des suggestions ont été formulées sur les domaines d'intervention et l'approche à adopter. Le modèle d'IPME pour les pilotes d'hélicoptère *Sea King* constitue un produit livrable distinct en vertu du présent contrat.

Executive Summary

The Human Modelling Group (HMG) of the SMART (Simulation and Modelling for Acquisition, Rehearsal and Training) section at Defence Research and Development Canada (DRDC) Toronto contracted Human*systems* Incorporated® (Human*systems*®; HSI®) to conduct a hierarchical goal analysis and construct a human performance model of pilot activities associated with the Sea King helicopter. In particular, HMG wanted the human performance model to include activities surrounding Helicopter Deck Landing (HDL) aboard a Navy ship. Ultimately, this model would be used to control a simulated Sea King helicopter. The human performance modelling application used for this project was the Integrated Performance Modelling Environment (IPME).

An initial workshop was held, attended by the Scientific Authority (SA), IPME and Human Factors experts from Human*systems*®, and Subject Matter Experts (SMEs) with experience of Sea King helicopter operations and of modelling in IPME from TopAces. This workshop served to provide the top levels of the goal hierarchy and identify some aspects of the model that would require significant effort to address. This top level of goals was subsequently decomposed to various levels as required, forming the base for further, detailed goal analysis.

During the goal analysis, there was some debate about the relative importance of different goal sets. As a consequence, the hierarchy should not be considered strictly linear. Rather, any goal can trigger any other goal, making all goals both subordinate and superordinate, as the situation demands. Data was gathered from available sources, including SME input, documentation (e.g. training manuals), previous work completed on this subject (Churchill and Sawel, 2001), and educated guesses.

It was also recognised that the pilot model needed a 'mission' to fly. This mission was created, again based in part on previous work (Churchill and Sawel, 2001) and SME input, and also on documentation and descriptions of missions. The mission, however, represents a significant difference from previous attempts to model the Sea King. Rather than rigidly adhering to a timeline, all pilot actions are in response to 'external' events. These events could be simulated radio calls, the position of the helicopter, or a logical next step in a goal sequence.

This report describes the output from the goal analysis, the mission used to 'bound' the IPME modelling efforts, the data used to populate the IPME model, assumptions and approach used in the modelling effort, conclusions, and recommendations for follow-on work. With respect to the follow-on work, some suggestions are made regarding areas to focus on and approach to take. The IPME model of Sea King helicopter pilots forms a separate deliverable under this contract.

This work is part of a larger research project that is exploring means to develop affordable, competent, and believable computer generated forces, particularly for virtual operators where higher fidelity is required than is practicable with current synthetic environment modelling tools. The goal is to combine current practices of explicit rule and procedural modelling built using easy to use tools such as IPME with formal psychological models that will allow the resulting operator model to learn new rules and associations much as a person would, reflecting individual differences and human limitations resulting from both physiological and psychological constraints on performance.

This work was performed under contract number W7711-037859. The SA for this work was Mr Brad Cain of the Simulation and Modelling for Acquisition, Rehearsal and Training (SMART) section.

Sommaire Administratif

Le groupe de modélisation de l'humain (GMH) de la section SMARE (simulation et modélisation pour l'acquisition, la répétition et l'entraînement), à Recherche et développement pour la défense Canada (RDDC) Toronto, a attribué un contrat à Humansystems Incorporated (HSI) pour effectuer une analyse hiérarchique d'objectifs et construire un modèle de performance humaine pour les activités des pilotes liées à l'hélicoptère *Sea King*. Plus particulièrement, le GMH voulait que le modèle de performance humaine comprenne les activités menées lors de l'atterrissage sur une héliplate-forme à bord d'un navire de la Marine. En bout de ligne, ce modèle servirait à contrôler un hélicoptère *Sea King* simulé. L'application de modélisation de la performance humaine utilisée pour ce projet était l'environnement intégré de modélisation de la performance (IPME). Un atelier initial s'est tenu et a regroupé l'autorité scientifique (AS), des experts de Humansystems en matière d'IPME et de facteurs humains ainsi que des experts en la matière (EM) de TopAces ayant une certaine expérience des opérations d'hélicoptères *Sea King* et de la modélisation dans l'IPME. Cet atelier a permis d'établir les niveaux supérieurs de la hiérarchie des objectifs et d'identifier certains aspects du modèle qui nécessiteraient un travail considérable. Ce niveau supérieur d'objectifs a par la suite été décomposé en divers niveaux qui ont constitué la base d'une autre analyse détaillée des objectifs.

Durant l'analyse des objectifs, on a débattu de l'importance relative des différents ensembles d'objectifs. Par conséquent, la hiérarchie ne serait pas considérée comme étant strictement linéaire. Plutôt, n'importe quel objectif peut en déclencher un autre, de sorte que tous les objectifs peuvent être à la fois subordonnés et superordonnés, selon la situation. Des données ont été recueillies des sources disponibles, notamment les commentaires des EM, la documentation (p. ex., manuels d'instruction), les travaux précédents effectués sur le sujet (Churchill et Sawel, 2001), ainsi que des hypothèses bien fondées.

On a également reconnu que le modèle de pilote avait besoin d'une « mission » de vol. Cette mission a été créée, et l'on s'est inspiré en partie, encore une fois, des travaux précédents (Churchill et Sawel, 2001) et des commentaires des EM ainsi que de la documentation et des descriptions de mission. Cependant, la mission est bien différente des tentatives antérieures de modélisation du *Sea King*. Au lieu de suivre un calendrier rigoureux, toutes les mesures prises par les pilotes sont des réactions à des événements « externes ». Il peut s'agir d'appels radio simulés, de la position de l'hélicoptère ou de la prochaine étape logique d'une séquence d'objectifs.

Le présent rapport décrit les résultats de l'analyse d'objectifs, la mission utilisée pour « limiter » le travail de modélisation de l'IPME, les données ayant servi à charger le modèle de l'IPME, les hypothèses et l'approche utilisées pour la modélisation, les conclusions et les recommandations pour le suivi. En ce qui concerne le travail de suivi, certaines suggestions ont été formulées relativement aux domaines d'intervention et à la démarche à adopter. Le modèle d'IPME pour les pilotes d'hélicoptère *Sea King* constitue un produit livrable distinct en vertu du présent contrat. Ce travail s'insère dans un plus vaste projet de recherche qui étudie des moyens de développer des forces produites par ordinateur qui soient abordables, compétentes et crédibles, surtout pour des opérateurs virtuels qui doivent compter sur une fidélité supérieure à ce qui est habituellement obtenu à l'aide des outils actuels de modélisation d'environnement synthétique. L'objectif consiste à combiner les pratiques actuelles de règles explicites et de modélisation procédurale, établies au moyen d'outils faciles à utiliser comme l'IPME, avec des modèles psychologiques officiels qui permettront au modèle d'opérateur obtenu d'apprendre de nouvelles règles et associations, tout

comme le ferait une personne, compte tenu des différences individuelles et des limites humaines découlant de contraintes à la fois physiologiques et psychologiques sur le plan de la performance.

Le présent travail a été effectué en vertu du contrat numéro W7711-037859. L'AS est M. Brad Cain de la section de simulation et modélisation pour l'acquisition, la répétition et l'entraînement (SMARE).

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1. Introduction

1.1 Background

Defence Research and Development Canada (DRDC) Toronto Simulation and Modelling for Acquisition Rehearsal and Training (SMART) group participate in an ongoing programme of research and development to improve training effectiveness. As part of this effort, the SMART group are developing methods to provide virtual pilot inputs to a simulated Sea King. This contract has supported this effort.

The contract objective in the Statement Of Work (SOW) is stated as:

> *"Create virtual Sea King flight crew pilot models (flying and non-flying pilot activities) in the Integrated Performance Modelling Environment (IPME) software that can be adapted by DRDC-Toronto to control a HDL (Helicopter Deck Landing) simulated Sea King."*

The flight crew models developed as a result of this present project will be integrated by DRDC-Toronto into a physical and virtual HDL simulation to study and demonstrate realistic human behaviour. Accordingly, it was essential that the network model did not confine its events to a specific scenario time line and that the model remained as flexible as possible to accommodate future DRDC-Toronto work.

This project had four main work items:

- **Work Task 1: High Level Goal Decomposition of Flight Crew Operations**
  Extend the preliminary BAe Systems Canada Inc (Churchill and Sawel, 2001) network model of flight crew operations during Helicopter Deck Landings to model, at a high level, a more comprehensive range of high level generic goals for flying and non-flying pilot activities.
- **Work Task 2: Further Goal Decomposition of Deck Landing Operations**
  Restructure the original BAe Systems Canada Inc (Churchill and Sawel, 2001) model by decomposing the original HDL aspects in further detail, taking into account the effects of the wider generic goals established in Phase 1.
- **Work Task 3 Information Flow Analysis**
  Identify information requirements and sources each goal/task in the new model.
- **Work Task 4: Construct the IPME software model.**
  Use the products of Work Items 1-3 to program an appropriate IPME software model.

This report describes the high level goal decomposition and the further goal decomposition for deck landing operations. This report also describes and presents the information flow analysis. The IPME software model constitutes a separate deliverable. Additional to these work items, this report also presents data collected from the running model, and describes the assumptions and decisions made in constructing the IPME model and the 'mission' that the IPME model is currently able to respond to.

The current project has been contracted to Humansystems Incorporated under contract no. W7711-037859/001/TOR. The Scientific Authority (SA) for this work is Mr Brad Cain.

1.2 Approach Taken in this Report

This report has eight main sections:

1. Introduction;
2. High level goal decomposition;
3. HDL goal decomposition;
4. HDL 'mission';
5. Information flow analysis;
6. Modelling approach and assumptions;
7. Runtime model data;
8. Conclusions and Recommendations for follow-on work.

These sections correspond to the work items described in the SOW, and important elements of the work that were necessary to consider to complete the work.

2. High Level Goal Decomposition

An overview of the high level goal decomposition is shown in **Figure 1**. At the top level, there are five main goals:

1. Determine what goal to pursue;
2. Fly the aircraft;
3. Maintain Situation Awareness (SA);
4. Operate aircraft equipment;
5. Conduct mission.

Aware of the questions regarding whether 'Fly the aircraft' is sub or superordinate to 'Conduct operations', it was thought that in certain situations any goal (at any level) could effectively be superordinate to any other goal (at any level) in that it can trigger another goal. Any goal could also be superordinate in that it may have a higher priority at a particular moment in time and therefore cannot be interrupted (even by a top level goal). Conversely, any goal can be subordinate to any other goal.

However, to address this point, it was thought worth putting in another top level goal 'Determine what goal to pursue'. This top level goal acts as a 'reception' area for all trigger stimuli in which decisions are made regarding whether ongoing goal achievement should be interrupted in favour of a goal associated with the new trigger stimulus. For instance, if the pilot is 'Conducting sonar operations' and a trigger stimulus occurs 'Attend to psychophysical indicators' (e.g. vibration), in this case the trigger stimulus would lead to the 'Conduct emergency procedures' goal, which is higher priority in all situations than 'Conduct sonar operations'. 'Conduct sonar operations' would be queued until such time as the 'Conduct emergency procedures' goal was satisfied (if the outcome of the 'Conduct emergency procedures' goal was the landing of the helo, then the 'Conduct sonar operations' goal would be left incomplete).

The goal hierarchy is broken down as appropriate (some branches are decomposed to the fourth level, others only to the second or even first). The hierarchy attempts to not have repeated instances of the same goal. For instance, goals that support 'Fly the aircraft' could also be repeated under each of the goals supporting 'Conduct operations'. Rather than do this, it was attempted to locate generic flying goals uniquely under an appropriate top level goal. A goal from any part of the hierarchy, and at any level of the hierarchy, may 'activate' goals elsewhere and at other higher or lower levels in the hierarchy, if required to satisfy that goal. For instance, 'Respond to comms' may trigger the 'Hover' goal, or the 'Descend' goal, or some such thing. Likewise some goals are not decomposed to the fourth level because they are served by goals elsewhere in the hierarchy. For instance, 'Manage Workload' is largely achieved through the goals under 'Determine what goal to pursue'. Likewise, 'Maintain SA' is achieved through instrument scans, external scans, maintaining comms, etc.

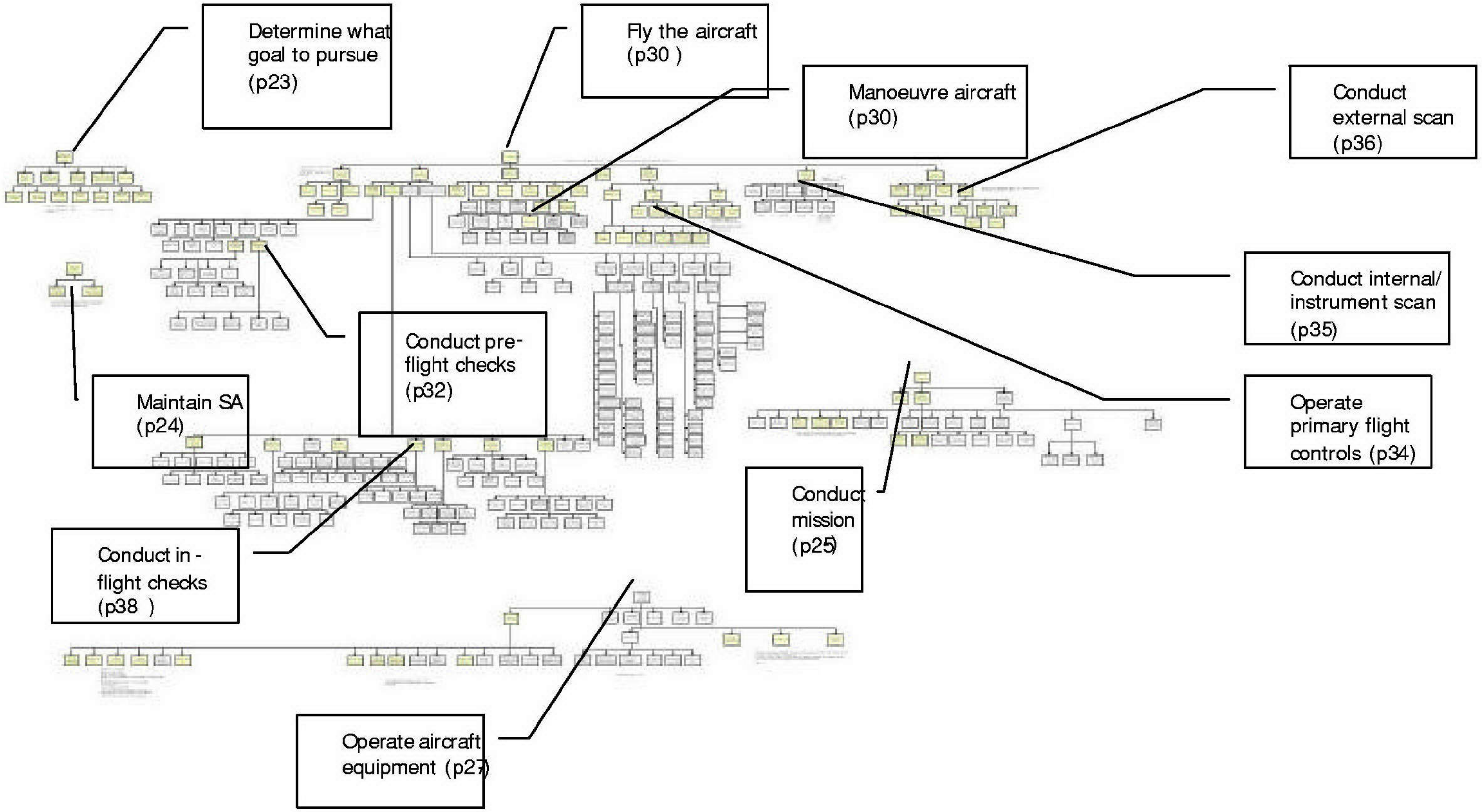

Figure 1: Overview of high level goal decomposition

The implication of the manner in which goals can interact is that there are several goals that must be continuously active in the background. For instance, ‘Determine what goal to pursue’ is continuously active, and its subgoals can be achieved in parallel with other goals, considering all trigger stimuli that enter the model. ‘Conduct operations’ is continuously active as a modifier for ‘Fly the aircraft’ but its subgoals may be queued in the event of a higher priority goal (e.g. ‘Conduct emergency procedures’ is a ‘Conduct operations’ subgoal, but will interrupt and queue another ‘Conduct operations’ subgoal). ‘Fly the aircraft’ is a continuous activity that is interrupted by nothing (apart from the end of the flight) and is triggered by nearly everything. ‘Maintain SA’ is a continuous activity whose characteristics may vary according to the situation (if necessary; e.g. if flying VFR then an explicit consideration of weather will be unlikely because a significant deviation from what is expected will be picked up naturally by the pilot). ‘Operate aircraft equipment’, although a significant goal, will only be active when triggered by another goal hierarchy.

In total, 317 goals were described.

The high level goal decomposition is presented in greater detail in Annex A.

3. Helicopter Deck Landing Goal Decomposition

As noted above, one objective of the goal decomposition was to be economical when identifying 'new' goals. For the most part, the HDL goal decomposition identified goals that already existed in various parts of the hierarchy. For instance, various calls from the Landing Signals Officer (LSO) were represented by the goal 'receive instructions'. The content of those instructions would be different for the HDL scenario compared to (for example) the receipt of re-tasking information while enroute from one point to another, but this can be differentiated in the scenario events file. Likewise, the pilot control of the cyclic, collective and pedals when landing on the ship were already represented, and the attention paid to external and internal visual signals was already represented.

It was possible to decompose the HDL scenario to a very fine level of detail (e.g. move abeam the ship). However, decomposition of the HDL scenario further would have rendered the model more procedural than responsive, and thus less flexible than desired. It was decided that such goals could be included in the scenario events file to trigger goal-directed behaviours in the model, rather than hard-code the activities of the pilot model along a rigid timeline.

4. Helicopter Deck Landing 'Mission'

The SOW for this contract required that a working IPME model be built from the outputs of the high level goal analysis, the specific HDL goal analysis and the information flow analysis. It was decided that a 'mission' would be required to create this model. In particular, this 'mission' would allow the analyst to determine which goals and relationships to model in detail, as appropriate to the time and level of effort available.

The 'mission' chosen needed to be extensive enough to exercise the goals involved in piloting a helicopter, but focussed enough to be achievable within the short timescales of this project. It was decided that the mission should comprise the Sea King taking off from the ship, flying a circuit (5 mile width and 10 mile length) and arriving back at the ship to land. This mission would demonstrate the model's ability to simulate human control of flying activities, their internal and external scan, response to incoming stimuli, and following of plans and procedures.

However, the 'mission' does not require exhaustive modelling in IPME to be completed. It does however point to the structure of the model required to achieve the DRDC aims of controlling a simulated helicopter. These indications informed that structure of the model such that future adaptation, calibration and extension can be achieved easily through substitution of bits of the model or addition (as opposed to entirely rebuilding the model).

The 'mission' is presented in Annex B.

The constructed model has been run in both IP/PCT and IPME modes and the mission successfully achieved several times. Some data from one of these runs is presented in Section 7.

5. Information Flow Analysis

The information flow analysis represented an important contribution to the IPME model construction. Specifically, it provided information regarding how the goals related to each other on a number of dimensions. The information flow analysis was also used to structure information pertaining to Visual, Auditory, Cognitive and Psychomotor (VACP) workload, goal duration, and other goal attributes.

In practice, a Microsoft Excel spreadsheet was prepared in which all 317 goals were listed down the left side, and information about the goals which would contribute to the IPME model was listed across the top. This meant that each row contained information about a single goal, as described by the column heading. The column headings came from three sources: the BAe Systems Canada Inc report (Churchill and Sawel, 2001) on the IPME model created for a previous contract (2001); IPME dialogue box fields; and the requirement of the modelling effort itself.

In total, there are 25 column headings, as described in Table 1.

No.	Column Heading	Description
1	Goal ID	Numbered so as to identify a goal's location in the hierarchy (e.g. 1. denoting a top level goal; 1.1 denoting a first level goal constituting part of the top level goal; 1.1.1 denoting a second level goal constituting a part of the first level goal; etc.).
2	Goal	The name given to the goal.
3	Average time to complete	The average time to achieve a goal, measured from start to completion, if calculable.
4	Standard Deviation of time to complete	Standard deviation of above (i.e. average variability in completion times).
5	Release conditions	What conditions must be met to consider a goal achieved. This can be used with or without 'average time to complete'.
6	Beginning effects	Other goals/events that are triggered by the commencement of the pursuit of a goal.
7	Ending effects	Other goals/events that are triggered by the completion of the pursuit of a goal.
8	Definition of failure	Possible outcomes that would be deemed failure to achieve the goal.
9	Probability of failure	The likelihood that a goal will fail to be achieved. This can be used with or without 'definition of failure'.
10	Consequences of failure	Other goals/events that are triggered by a failure to achieve a goal. Can take a variety of forms but will include triggering alternative goals, or passing forward error data through the IPME model to produce a different outcome.
11	Task degradation	Goal(s) that will be triggered if performance in pursuit of a goal degrades.
12	Continuous/discrete/ repeated	Definition of whether the goal is continuous (always active), discrete (undertaken when required), or repeated (undertaken at regular intervals).
13	Related scenario events	Stimuli that trigger goal pursuit (e.g. radio calls, locations, visual references).
14	Climb/descent rate	When appropriate, the climb/descent rate that will be used.
15	Turn rate	When appropriate, the turn rate that will be used.
16	Performance shaping factors	Factors that can affect performance in terms of efficiency, accuracy, failure, etc. (e.g. fatigue, emotion, training, team cohesion).
17	Visual demand	Rating on a scale of 1 to 7 (see Table 2).
18	Auditory demand	Rating on a scale of 1 to 7 (see Table 2).
19	Cognitive demand	Rating on a scale of 1 to 7 (see Table 2).
20	Psychomotor demand	Rating on a scale of 1 to 7 (see Table 2).
21	Priority	Rating on a scale of 1 to 8 (see Table 3).

No.	Column Heading	Description
22	Interruptable	Yes/no statement regarding whether a goal can be interrupted by another goal (assuming it is of higher priority).
23	Resumable	Yes/no statement regarding whether an interruptable goal can be resumed after the interruption.
24	Sheddable	Yes/no statement regarding whether a goal can be discarded entirely if priorities make this a possibility.
25	Shed if late	Yes/no statement regarding whether a goal can be discarded entirely if it is likely to be begun late.

Table 1: Information collected for each goal

The VACP demand ratings (column numbers 17 – 20) are provided in Table 2.

Ordinal rating	Interval rating	Descriptor
		Visual modality – unaided (naked) eye
1	1.0	Register/detect (detect occurrence of image)
2	1.4	Read (symbol)
3	2.5	Scan/search/monitor (continuous/serial inspection, multiple conditions)
4	4.6	Inspect/check (discrete inspecton/static condition)
5	5.2	Discriminate (detect visual difference)
6	5.5	Track/follow (maintain orientation)
7	7.0	Locate/align (selective orientation)
		Auditory modality
1	1.0	Detect/register sound (detect occurrence of sound)
2	1.2	Verify auditory feedback (detect occurrence of anticipated sound)
3	4.4	Orient to sound (general orientation/attention)
4	4.8	Interpret semantic content (speech)
5	5.0	Orient to sound (selective orientation/attention)
6	6.5	Discriminate sound characteristics (detect auditory differences)
7	7.0	Interpret sound patterns (pulse rates, etc.)
		Cognitive modality
1	1.0	Automatic (simple association)
2	1.2	Sign/signal recognition
3	2.0	Alternative selection
4	4.1	Estimation, calculation, conversion
5	4.6	Evaluation/judgement (consider single aspect)
6	5.1	Encoding/decoding, recall
7	7.0	Evaluation/judgement (consider several aspects)
		Psychomotor modality
1	1.0	Speech
2	1.3	Discrete actuation (button, toggle, trigger)
3	2.6	Manipulative
4	3.1	Discrete adjustive (rotary, vertical thumbwheel, lever position)
5	3.8	Continuous adjustive (flight control, sensor control)
6	4.7	Serial discrete manipulation (keyboard entries)
7	7.0	Symbolic processing (writing)

Table 2: VACP demand ratings (after Churchill and Sawel, 2001)

The descriptors used for rating priority are provided in Table 3.

Value	Descriptor
1	Requires instant reaction; critical for crew survival; no delays or interruptions acceptable
2	Requires priority attention; user can delay briefly at outset; interruptions not acceptable
3	Requires priority attention; slightly longer delay at outset is acceptable; interruptions not acceptable
4	Longer delay at outset is acceptable; task may or may not be interrupted
5	Window for completion set by external factors; tasks may or may not be interruptable/sheddable
6	Continuous task
7	Repeating task
8	Low priority; may be interrupted/shed
9	Externally initiated visual detection task; not interruptable/sheddable

Table 3: Descriptors used for priority

Of the 317 goals identified, it was the intention to provide information about every one individually. However, often top level goals are summations of their constituent goals, a pattern that repeats through every successively decomposed level in the hierarchy. Further, it was beyond the scope of this contract to collect actual performance data regarding the identified goals. The data included in the spreadsheet (in Annex C) represents an educated guess by a Subject Matter Expert (SME, in this case a former Sea King pilot). It is anticipated that some data will be refined as DRDC Toronto embark upon their research programme using this model.

6. Modelling Approach and Assumptions

In accordance with the wishes of the DRDC Toronto SA, and to ensure compatibility with the long-term research agenda (using the model) of DRDC Toronto, the modelling effort attempted to build a model that was responsive to incoming stimuli (triggers in the scenario). In other words, the model does not proceed along a rigid timeline onto which are hard-coded both scenario events and operator actions. Rather, the operator model can pursue any goal at any time, provided it is triggered by some stimulus. The nature of this stimulus could be visual, auditory, proprioceptive, physical, cognitive (in terms of plans (e.g. at location turn right) or procedures), etc. The model then determines what goal is most appropriate and then activates that goal. This results in a model that is flexible and thus more closely approximates 'real' human performance.

A great deal of time and effort was devoted to developing the pilot model for controlling the flight of the aircraft. This high level goal represents a significant modelling challenge: to represent the coordinated movement of feet and hands to move the helicopter to some location. Further to this, the pilot must make decisions regarding when to accelerate, when to decelerate, when to climb, when to descend, when to turn, in which direction to turn (i.e. left or right) and when to rotate in position. Other activities, while amenable to parallel execution, do not necessarily have such a fundamental impact on other goals. For the purposes of this 'mission', it was felt that the pilot model for control of the aircraft was the single-most important aspect, and all other goals fed or modified this goal (in both IP/PCT and IPME modes).

In building the model, a number of assumptions were made to ensure best use was made of the SME's time. These assumptions can be rectified if they were inappropriate. In all instances, the ability to change features of the model easily was a prime consideration. For ease of consideration, these assumptions are listed below:

1. The 'mission' as described in Annex B is not subject to any complicating factors (e.g. wind, sea state, etc.).
2. There are no failures or emergencies in this mission and none have been modelled.
3. Only scenario events directly related to the 'core' mission are modelled (e.g. 'receive comms', 'visual contact', etc.).
4. There is no consideration of Performance Shaping Factors because performance in this model will be perfect.
5. Scenario events will be dependent on the aircraft position relative to the ship, radio calls, and visual cues.
6. For the purposes of this scenario, the ship is steaming due north at a steady 18 kts.
7. Wind direction will not change relative to the position of the ship.
8. Wind speed will have no effect on acceleration, deceleration, turn rate, or lift of the helicopter.
9. Some data was gathered from the BAe Systems analysis - where several of their tasks correspond to one of the goals described for this project, the sum total of time to complete and the highest VACP demand listed were taken.
10. The throttle is set to full from the outset. Therefore no goal to do with throttles is included in the hierarchy or IPME model.
11. Cyclic control will usually be toward a vector (value and direction) as an endstate (or maintenance of same).

12. Exception to cyclic end state will be sideways and backward hovers, which will be to a position.
13. Collective control will usually be toward an altitude as an endstate (or maintenance of same).
14. Pedal control will usually be toward a heading as an endstate (or maintenance of same).
15. Cyclic will control acceleration in any direction in the lateral plane.
16. Collective will control acceleration in the vertical plane.
17. The effect of gravity (-9.8 m/s^2) is negated at 85% collective.
18. Maximum vertical acceleration (100% collective) is 1.73 ms/s (based on a calculation of 85% collective = 9.8 m/s^2 – 100% = 1.73 m/s^2).
19. Pedal will control rotational acceleration in the horizontal plane.
20. Torque is 5° $/s^2$, anti-clockwise.
21. Pedals are modelled such that full left = 100% and full right = 0%. Neutral = 50%.
22. Pedal inputs from 51%-100% inclusive = 7.2°$/s^2$ anti-clockwise; pedal inputs from 49%-0% inclusive = 7.2°$/s^2$ clockwise. Therefore maximum acceleration in either direction will be 360°$/s^2$.
23. Normally, the range of pedal input will be 50%+/-20%.
24. Cyclic, collective and pedal movement occur along a 0 – 100 (zero to one hundred) scale, where 0 is no input and 100 is maximum input.
25. Cyclic movements can occur in both the X and Y axis; the X axis is left/right, the Y axis is forward/backward. The cyclic can move from -100 to 100 along either of these axes.
26. Main Rotor Blade (MRB) angle can vary by 15° from the horizontal in any direction but is normally restricted to between 0° and 7°.
27. Two flight modes are supported: hover and flight. When turning in hover, the helicopter will rotate around a point; cyclic inputs will cause the helicopter to move in that direction (i.e. without turning to face that direction). When turning in flight, the helicopter banks like a fixed-wing aircraft and comes around to face the new direction. In flight mode, inputs to the cyclic are generally only forward in the Y axis and left or right in the X axis (i.e. large diagonal inputs are not made).
28. Progression from zero m/s^2 acceleration to x m/s^2 acceleration will be instantaneous; progression from x m/s^2 acceleration to zero m/s^2 acceleration will be instantaneous. This means a speed, once reached can be held without any complicated calculus to determine how the control will be used to approach and then hold that speed.
29. There is no 'Planning' goal in the hierarchy. Although not entirely necessary within the context of this mission, it may be a good thing to add at some point in the future. It could be modelled according to the different events you would plan for, with correspondingly different completion times and VACP values.

It is expected that this information regarding the modelling approach and assumptions made will enable future work to target specific areas that require modification.

7. Runtime Model Data

The constructed model of Sea King helicopter pilot activities has been run several times, both for debugging purposes and to gather data. When run, the model attempts to achieve its mission, which is to fly the helicopter according to a small set of built-in rules (e.g. how to take off and land when at sea) in order to pass a number of waypoints. These waypoints and the pilot-model's understanding of them can be thought of as corresponding to a real pilot's flight plan.

The manner in which the mission is achieved is not hard-coded on a timeline; if this were the case model 'control inputs' would be precise and discrete. The control inputs in this model show anticipation of meeting goals and a commensurate 'easing off' on controls, as well as over- and under-compensation in control inputs. These are features of real human performance (e.g. pilot biases) and can be easily modified in the pilot model.

The data here show the planned helicopter flight path (Figure 2), the actual helicopter flight path (Figure 3), the various positions of the cyclic (Figure 4), and the speed of the helicopter (Figure 5). Each of these will be briefly described.

One further aspect of the model's implementation, not represented by the data here, concerns the cognition that is assumed to underlie all pilot performance. As noted previously, the goal "Determine what goal to pursue" acts as a trigger for all activities. This has been implemented in such a way as to interact with incoming stimuli and the situation awareness goals of determining an expected value and comparing observed values with expected values. This little loop will prove fundamental in the future for developing the model into one that is responsive to a wider range of natural helicopter pilotage events.

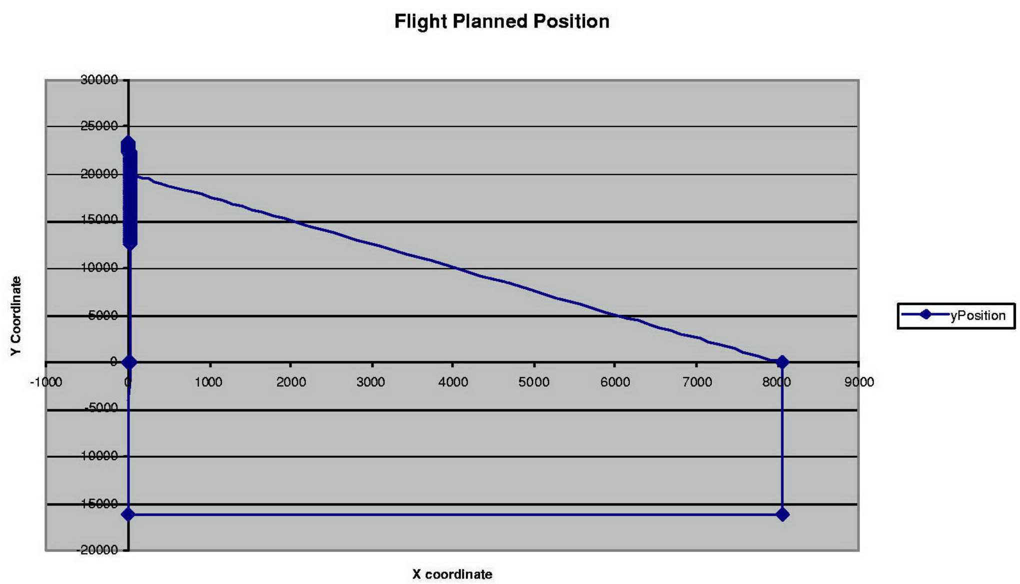

Figure 2: Helicopter flight planned position

In Figure 2 the waypoints to be followed by the helicopter are displayed. These include many around the ship itself (corresponding to standard procedures when approaching or leaving a ship at sea). Additionally, a waypoint was placed to the North of the ship as an aiming point for initial acceleration (hence the immediately obvious difference between Figure 2 and Figure 3). This waypoint is not reached in the actual data. The sharp corners of this plot can be contrasted with the plot of actual helicopter position (Figure **3**), in which it is apparent the helicopter 'flies' a turn past waypoints.

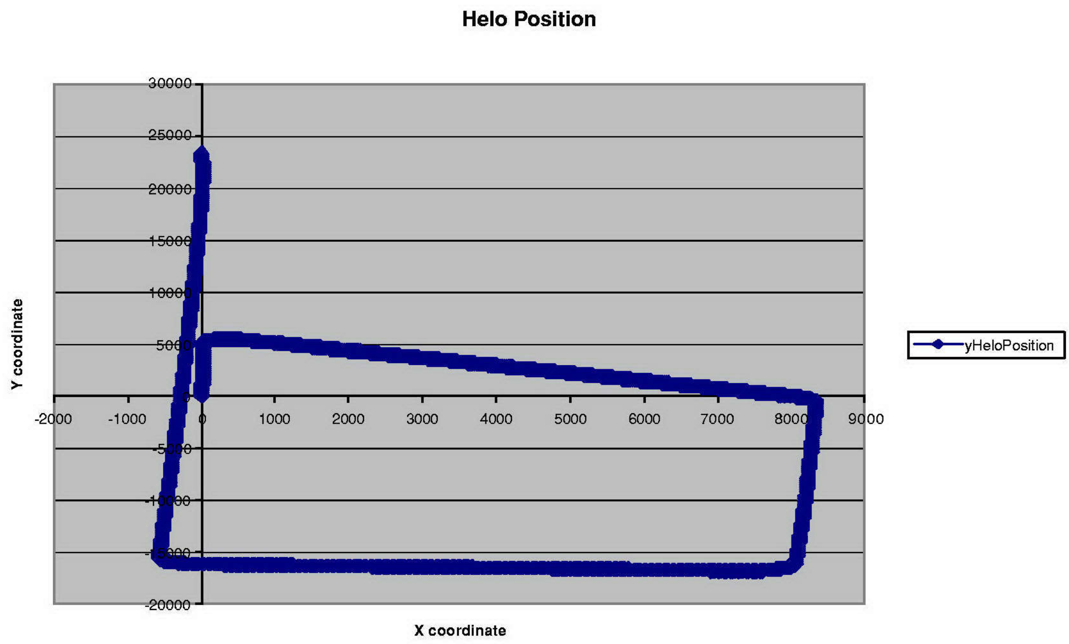

Figure 3: Actual helicopter position

In this plot (Figure 3) it is apparent that the helicopter follows the ship, slips off to the right, accelerates forward, and then turns right to pursue its waypoints. The contrast with the flight planned route (Figure 2) is apparent.

The plot of cyclic movement (Figure 4) shows that the pilot makes a number of different types of movement, from small to large, in all directions, including directions not exclusively on the X or Y axis. Further, it is possible to conclude that the pilot model engages in two sorts of cyclic input, for hovering flight and for flight as a 'fixed wing' aircraft. The regular pattern exhibited by cyclic inputs to the right reflects the 'fixed wing' aspect of flight, when the helicopter is following its waypoints in the circuit. The erratic pattern exhibited by cyclic inputs to the left reflects the hovering aspect of flight when the helicopter is approaching the ship, traversing across the deck and attempting to centre itself over the bear trap. It is also possible to discern the efforts of the pilot to 'home in' on the correct position by using the cyclic.

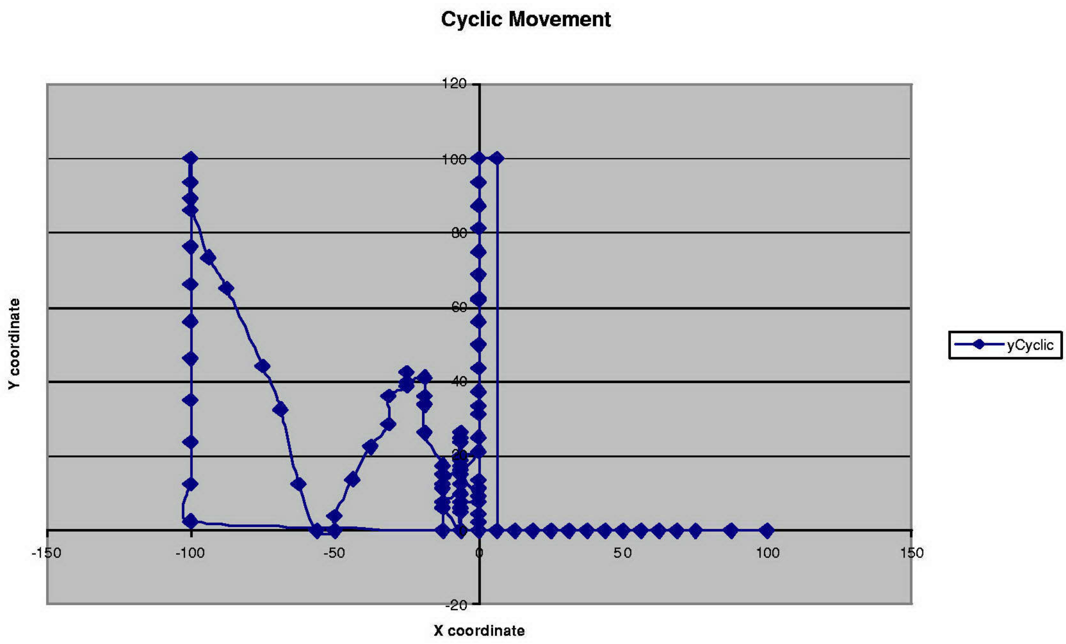

Figure 4: Movements of the cyclic to achieve the mission

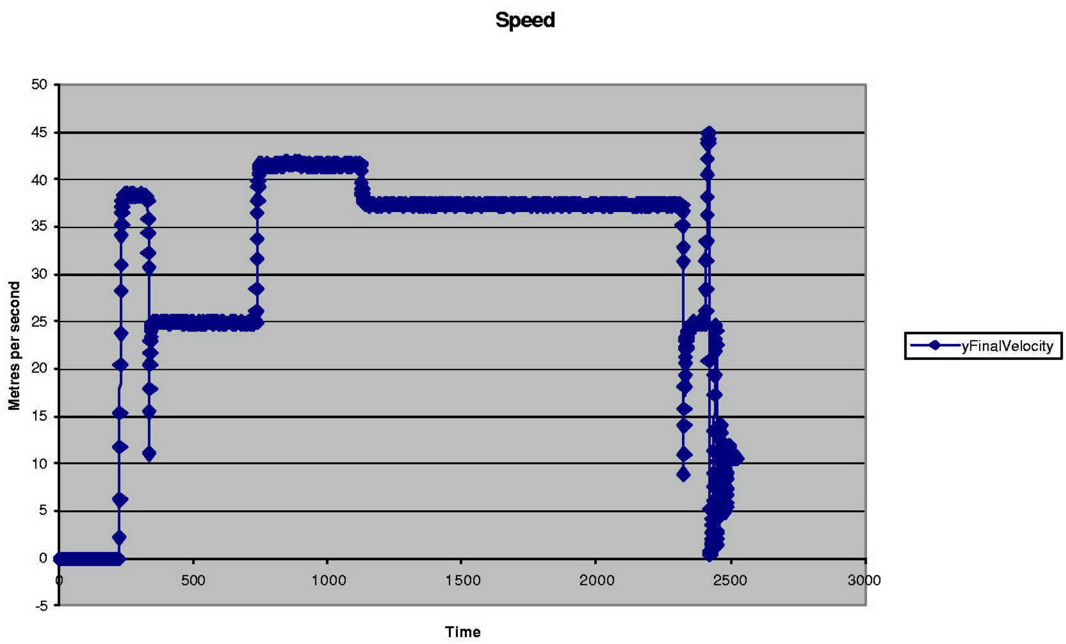

Figure 5: Speed of the helicopter

The plot of helicopter speed (Figure 5) clearly shows the take-off portion of flight as the helicopter hovers over the deck, and the hard acceleration after leaving the ship. The pilot model than reduces acceleration to such an extent that the speed actually drops. Variations in speed can be observed throughout the cruising phase of flight, with gross adjustments of speed being made very near the end of the flight. This corresponds to SME reports of how the helicopter is flown: the helicopter is accelerated forward from the ship to cruising speed, then minor adjustments are made throughout the flight. At the end of flight, the pilot is attempting to match the speed of the ship, and making strong, freque nt adjustments to its position in relation to the ship.

In summary, the data presented here show how responsive the helicopter pilot model is, and how closely it matches actual human performance. While calibration will be required to ensure the *magnitude* of pilot inputs matches real life, the *pattern* of inputs already reflects (SME-reported) actuality.

8. Conclusions and Recommendations for Follow-On Work

In the course of developing this model of Sea King pilot goal pursuit, a number of conclusions have been drawn:

- There are several different ways in which one can construct a hierarchy of goals;
- The manner in which the IPME model operates points to the notion that goals do not exist in a linear hierarchy. Rather, they appear to exist in non-linear relationships that may form opportunistically to satisfy the needs of the goal being pursued;
- For a Sea King pilot to decipher a stimulus in such a way as to trigger goal pursuit, a great deal of different information about current state and desired state must be considered in order to determine what goal to pursue;
- A comprehensive model of pilot behaviour, implemented in IPME, may be too unwieldy to run from a single computer (some computer crashes were experienced, notably in IP/PCT mode);
- All activities are being carried out by one pilot (in this model). Workload results may be unrepresentative because of this;
- A number of parameters in this model are based on educated guesses. Consequently, the model may return atypical results;
- The inputs by the pilot to the cyclic, collective and pedals are most important in this model. Other control inputs by the pilot serve to modify or support these primary control inputs;
- This model has been constructed to be responsive to inputs to the model. A model predicated on a rigid timeline of events and activities could not be so responsive;
- This model has been constructed with the greatest emphasis on goals directly related to controlling the aircraft;
- This emphasis is then applied to the particular mission of taking off, flying a circuit, and landing on board a ship;
- Other goals associated with pilot activities have been modelled, but largely act as workload contributors;
- The model provides an organisation through which to guide future research efforts aimed at helicopter pilot training and development.

Although there is a great deal of follow-on work possible on the basis of this contract, there are a number of tasks that represent higher priorities, as their completion will render the model more responsive and more realistic:

- Fully model the hierarchies associated with the following top-level goals:
  - Determine what goal to pursue;
  - Maintain Situation Awareness;

(*this will require stimuli to be catalogued and associated with goals throughout the goal hieararchies. A short catalogue of stimuli and structure for linking stimuli to goals is provided at Annex D.*)

- Integrate the pilot model with a high fidelity simulation of a Sea King helicopter;
- Calibrate the pilot model inputs to the responses of the Sea King helicopter simulation.

After these recommended items of follow-on work are completed, the model can be extended as priorities dictate.

9. References

Churchill, L.L. and Sawel, R. (2001). Human Factors Engineering System Analysis of Sea King Deck Landing – Final Project Report. BAe Systems Canada Inc. report to DRDC under contract W7711-007686/A.

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Department of National Defence (1997). Pilots Check-List – CH124 Sea King Helicopter. C-12-124-A00/MC-001 (1997- 08-15).

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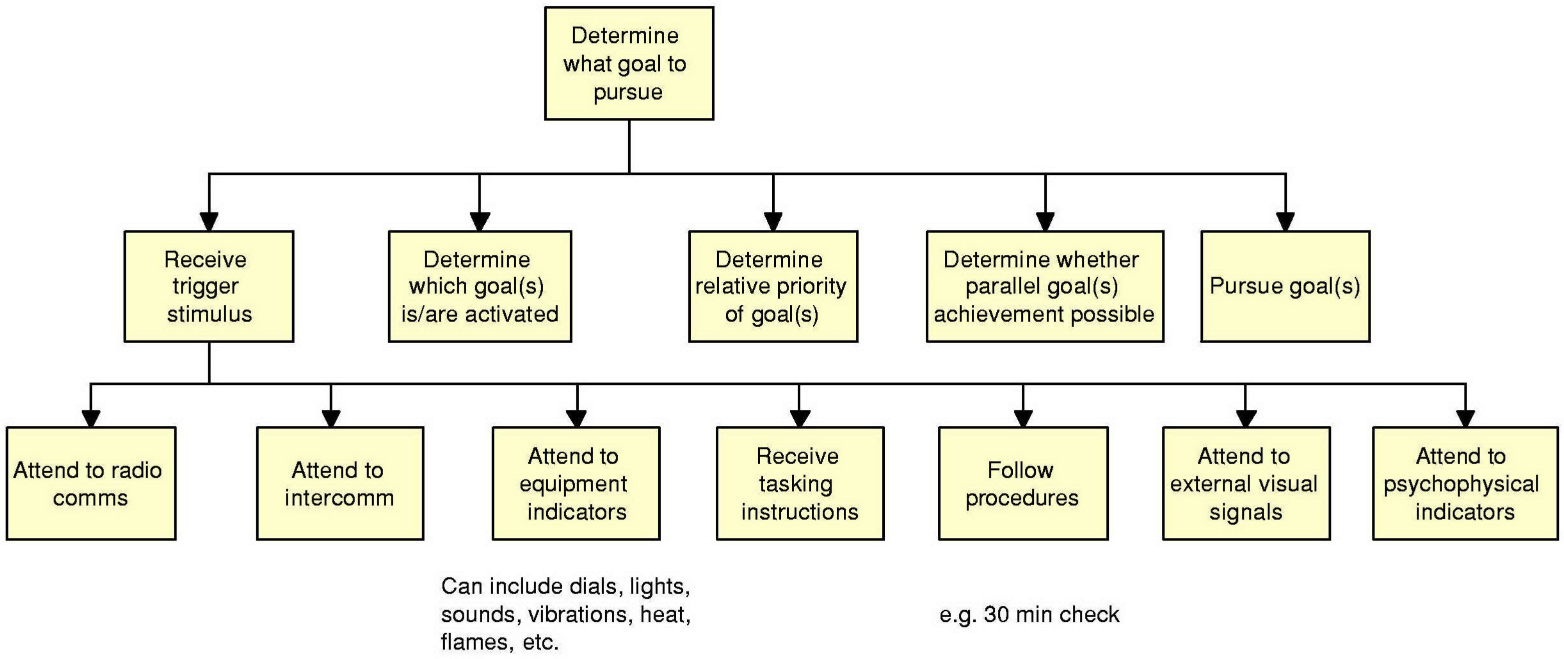
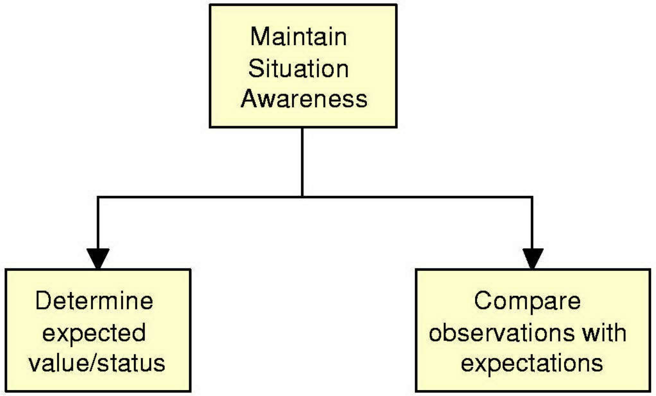
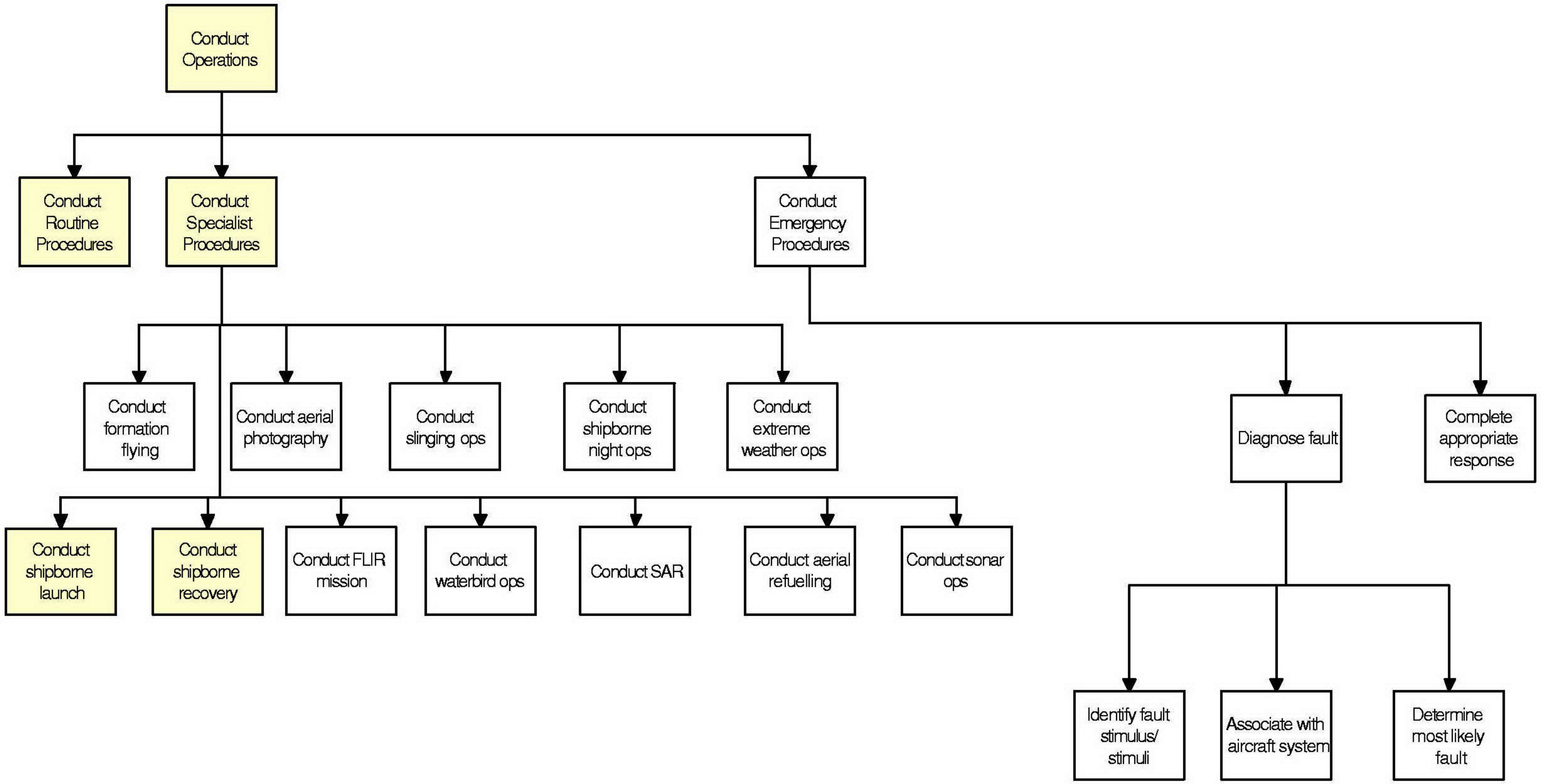
Annex A: High-Level Goal Decomposition


Determine what goal to pursue
Receive trigger stimulus
Determine which goal(s) is/are activated
Determine relative priority of goal(s)
Determine whether parallel goal(s) achievement possible
Pursue goal(s)
Attend to radio comms
Attend to intercomm
Attend to equipment indicators
Receive tasking instructions
Follow procedures
Attend to external visual signals
Attend to psychophysical indicators
Can include dials, lights, sounds, vibrations, heat, flames, etc.
e.g. 30 min check



Explain that these two goals apply throughout the hierarchy, therefore have put under SA to keep it as a higher level goal



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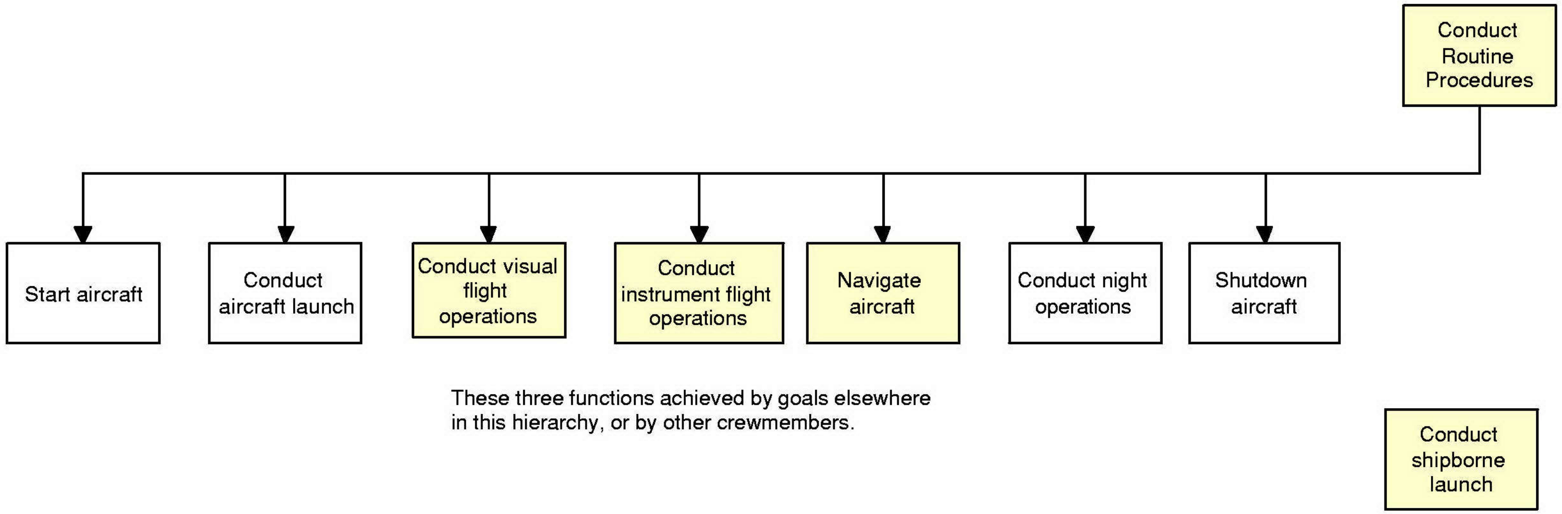
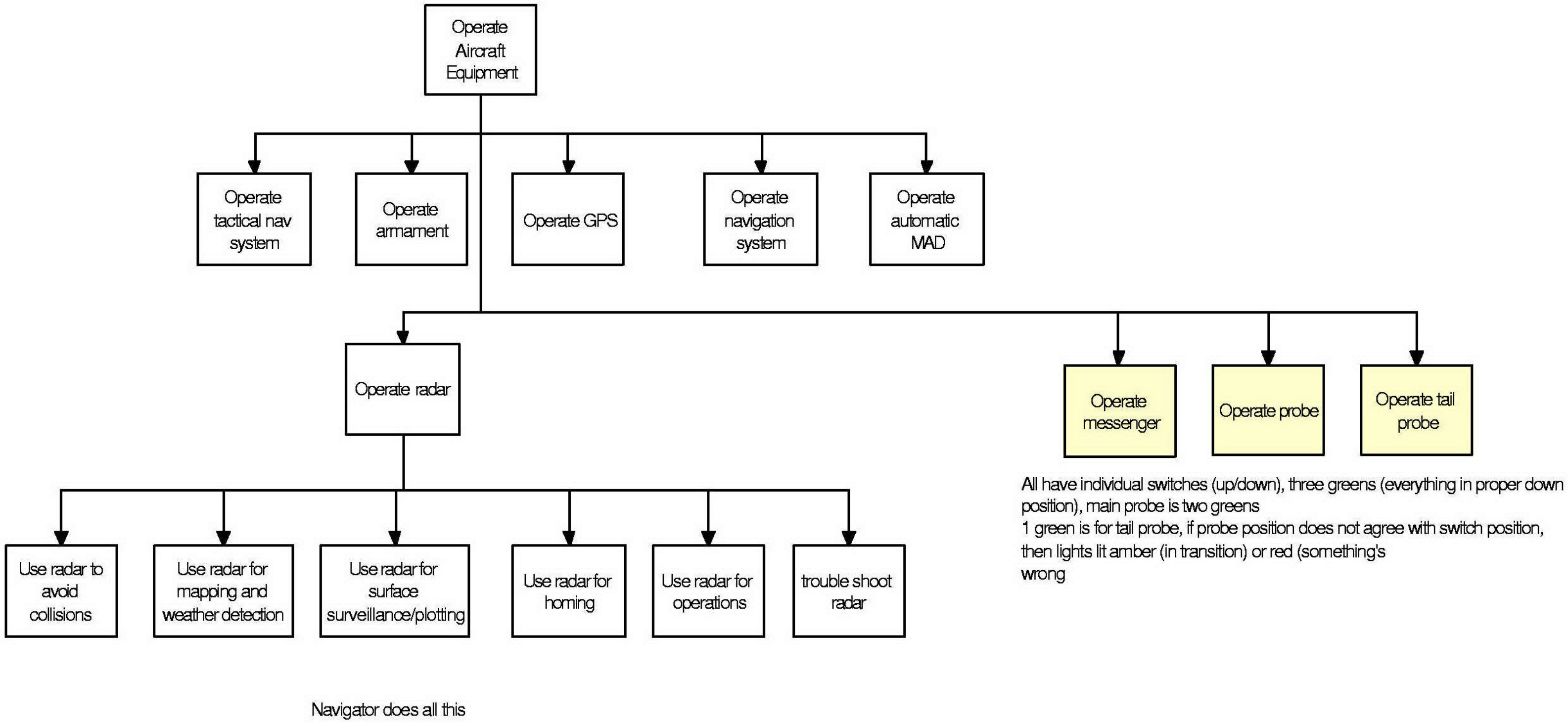

Conduct Routine Procedures
Start aircraft
Conduct aircraft launch
Conduct visual flight operations
Conduct instrument flight operations
Navigate aircraft
Conduct night operations
Shutdown aircraft
These three functions achieved by goals elsewhere in this hierarchy, or by other crewmembers.
Conduct shipborne launch



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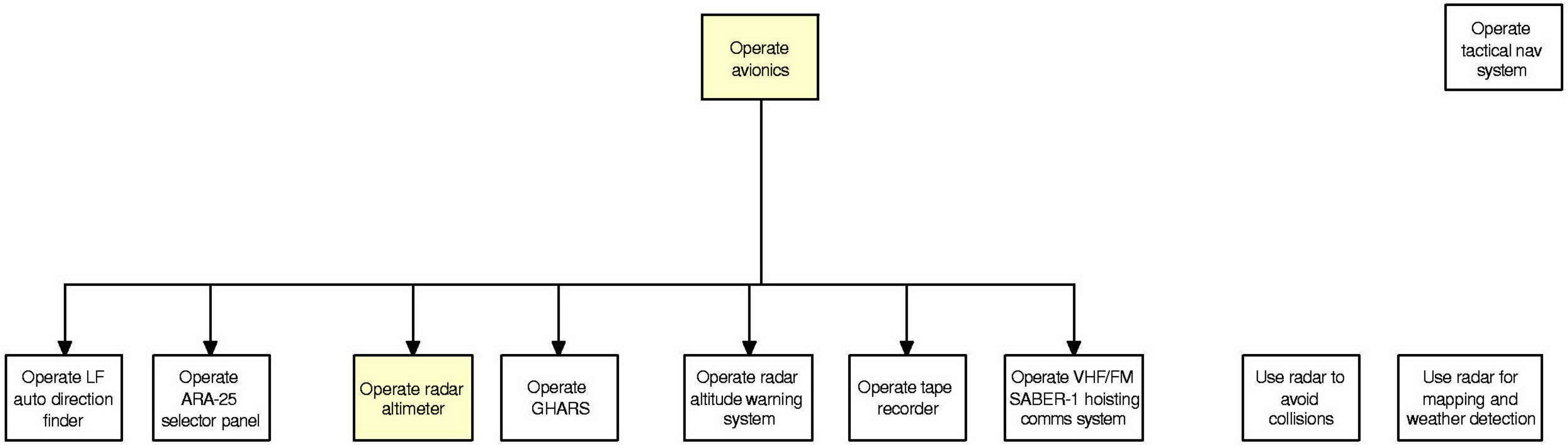

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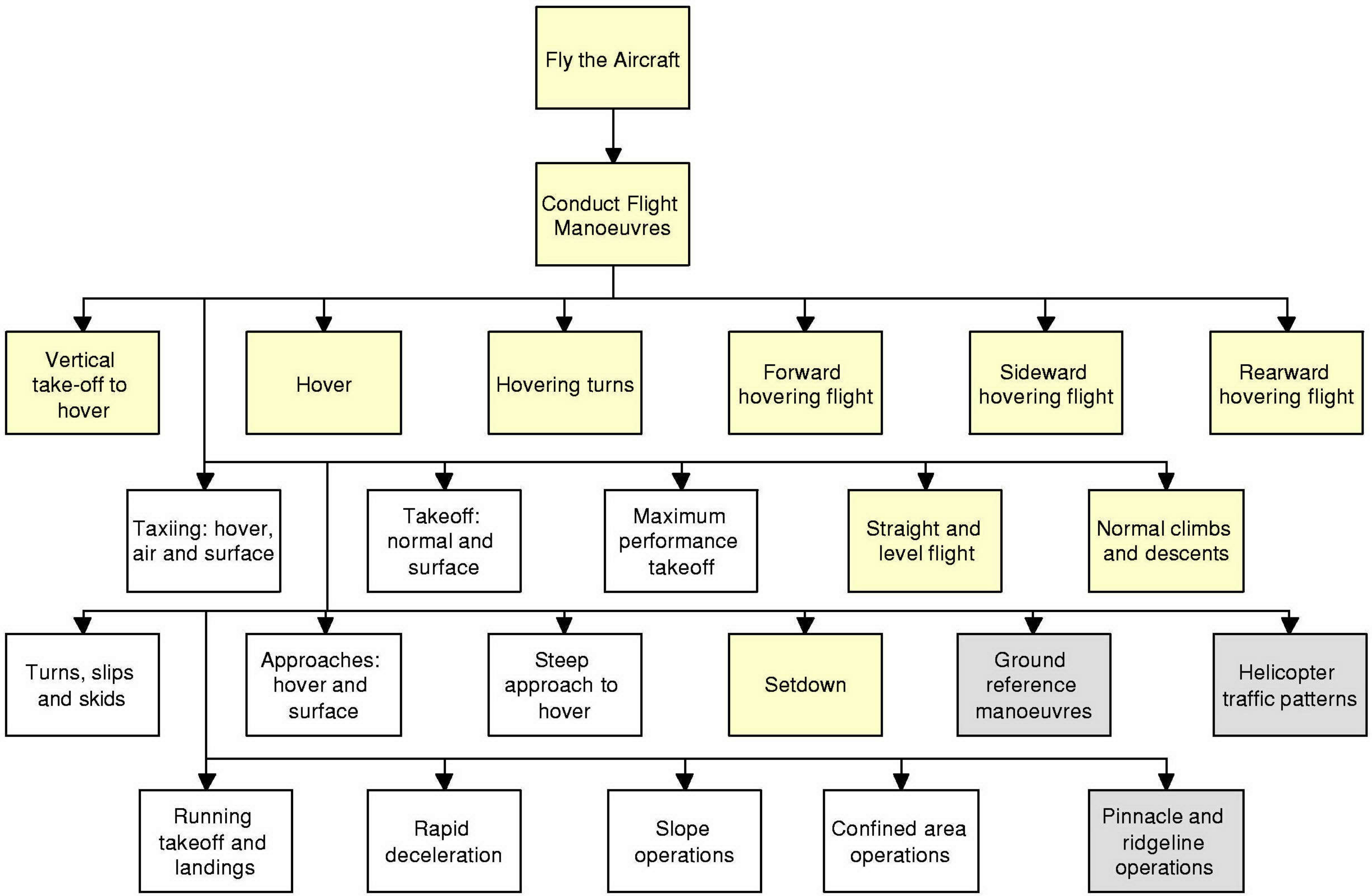
General: Turn on set
Select correct radio
Select correct setting
Select Fx (not ICS)(dial in thumb wheels or rotary dial)
Set volume
Depress ICS/Radio switch to ICS or Radio
(Turn off set)
Speak into microphone
For HF, check people are away from the left side of the helo, and away from the HF] coupler - do not do when on the ground

To operate also covers looking at an instrument and considering the information provided



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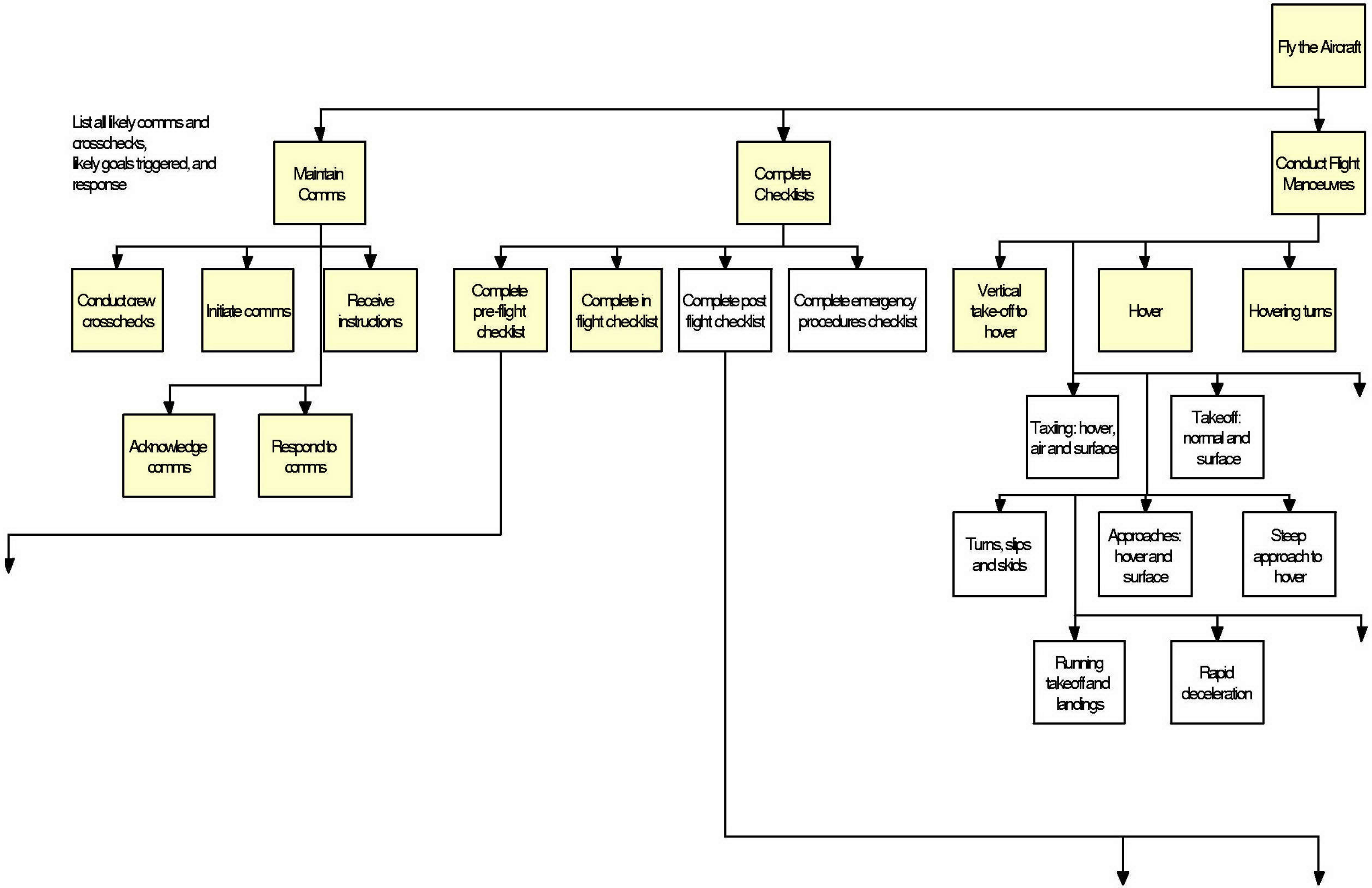

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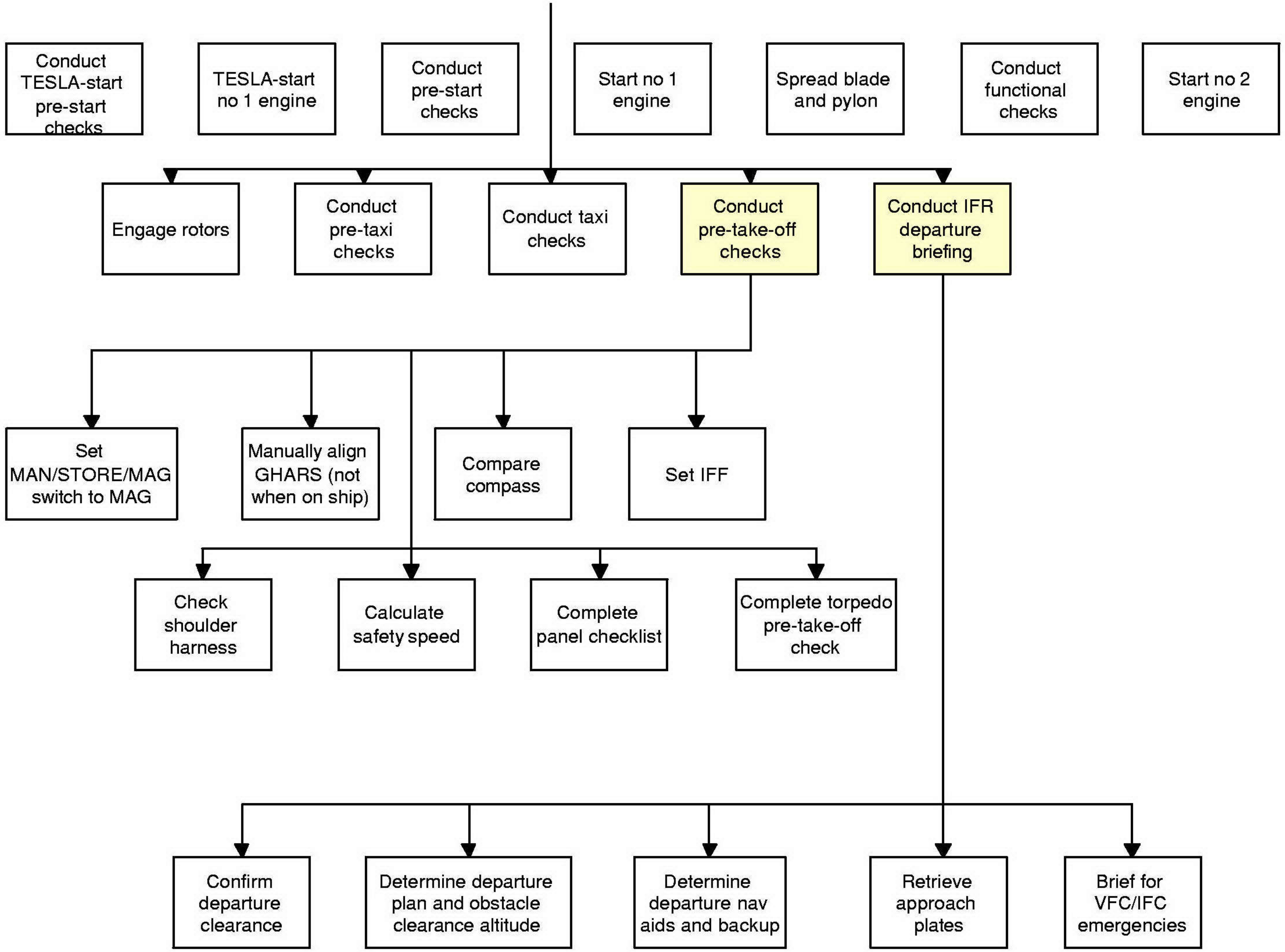

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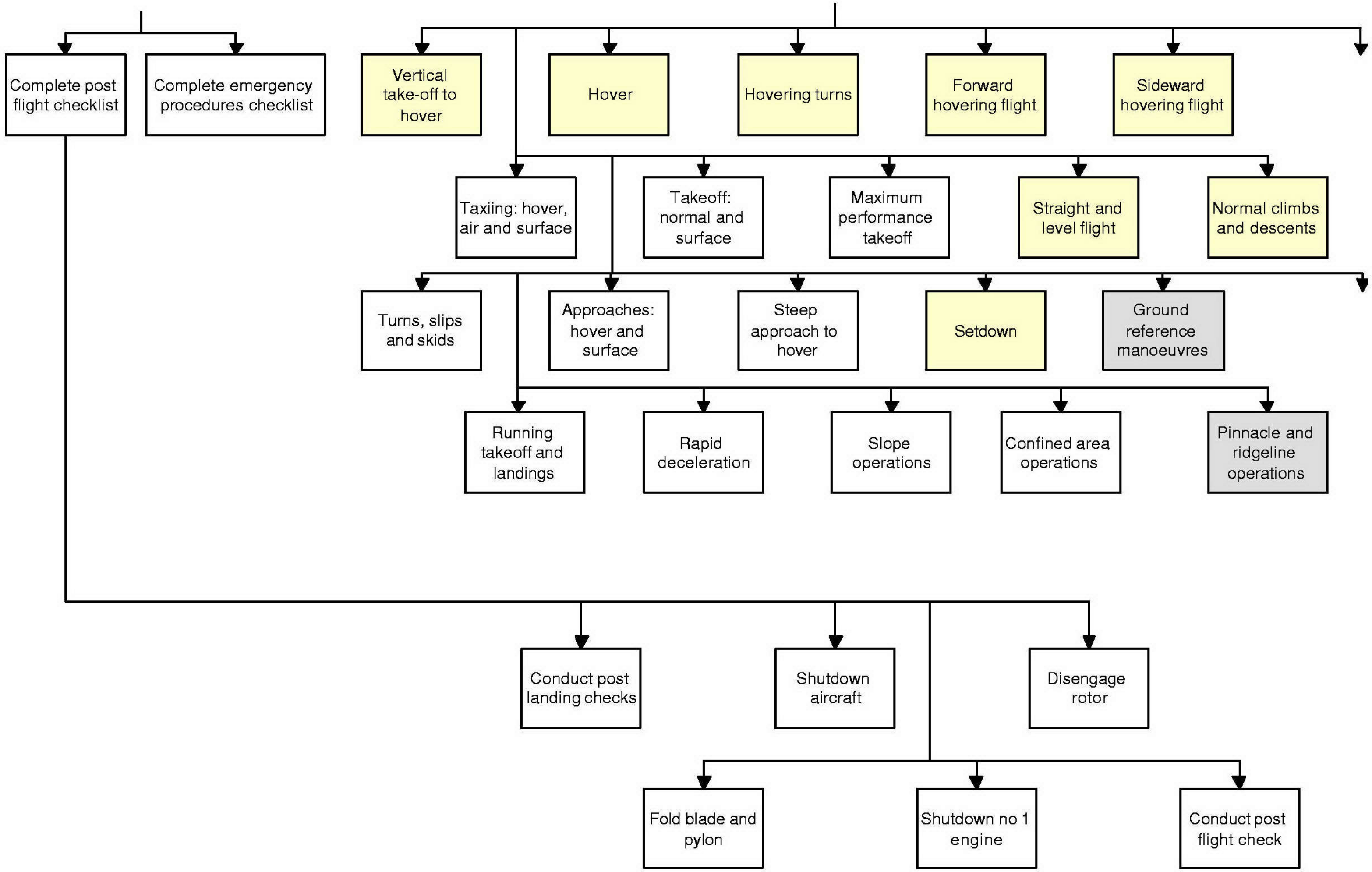

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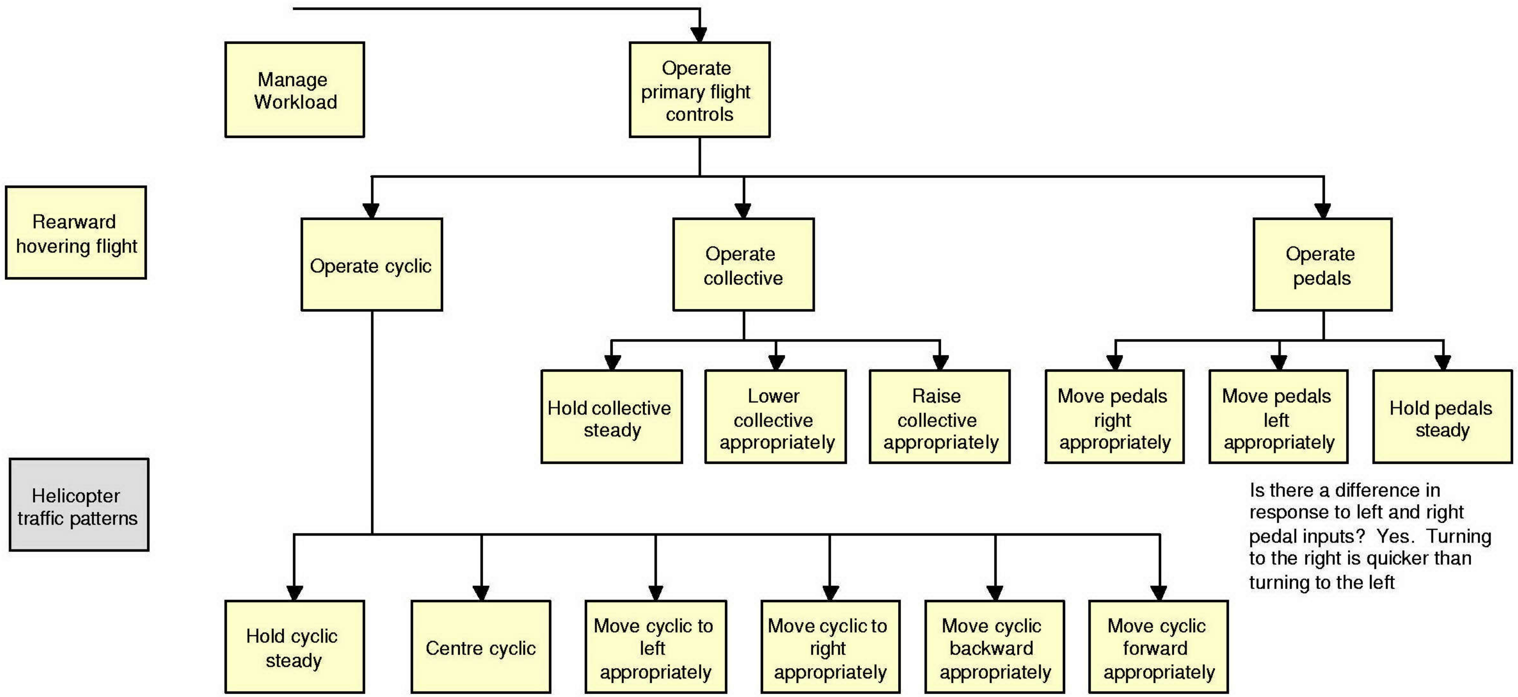
Probably more top level than this. Maybe invoking prioritisation and scheduling. Move???



radio, intercomm, weapons drop, trim (ASE) control, main probe release

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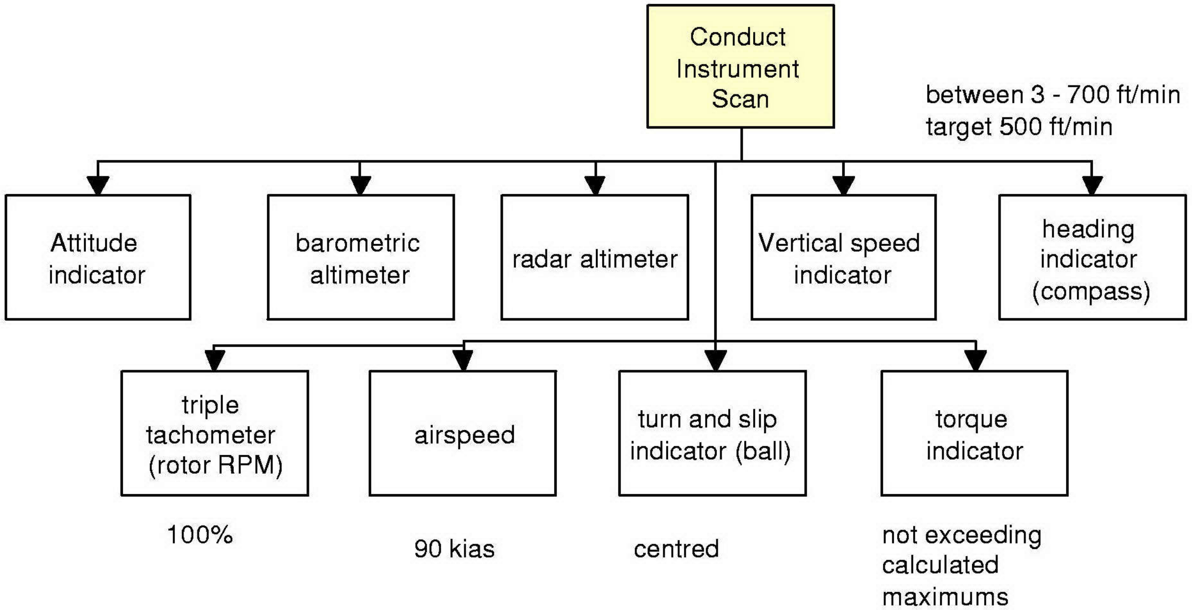

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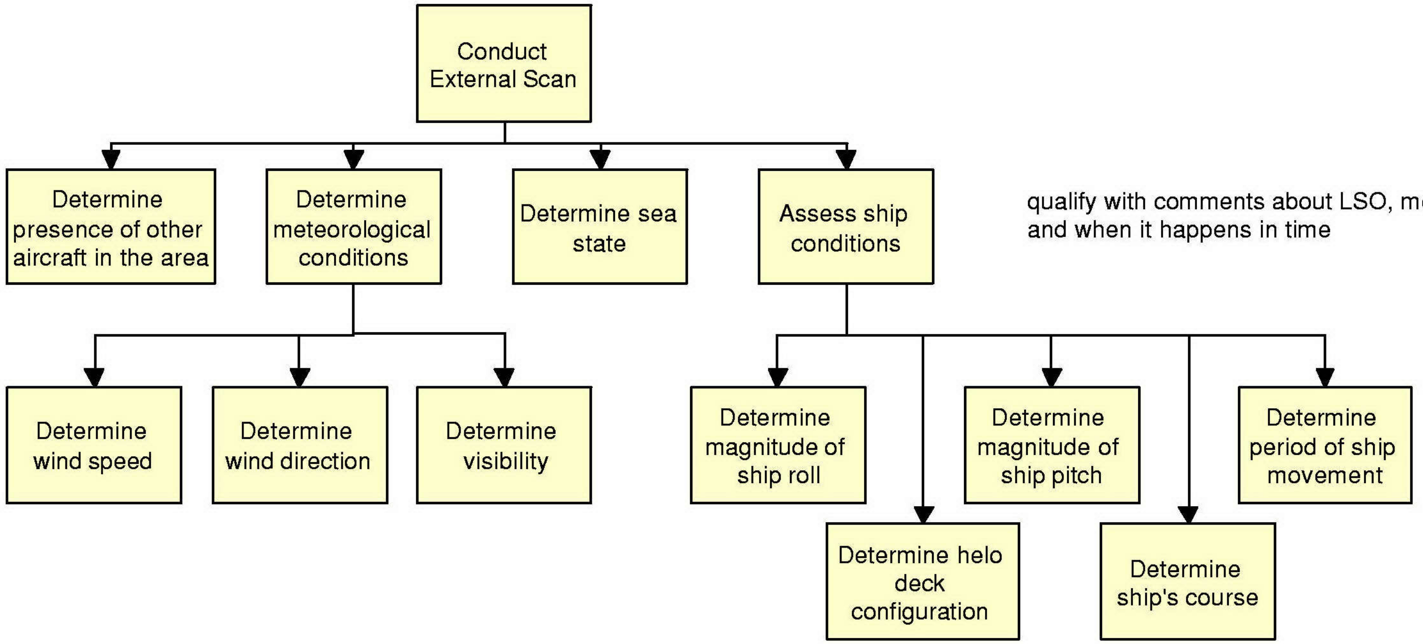

qualify with comments about LSO, mental picture and when it happens in time

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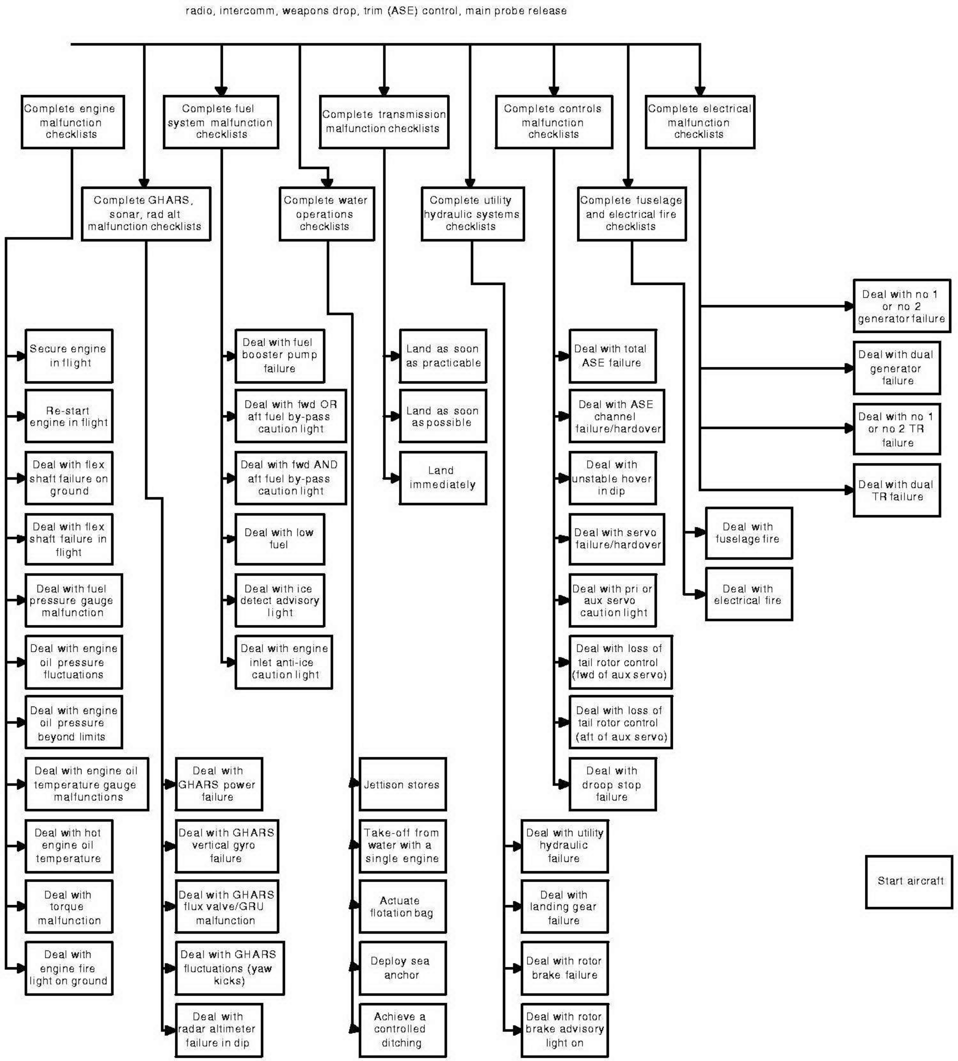
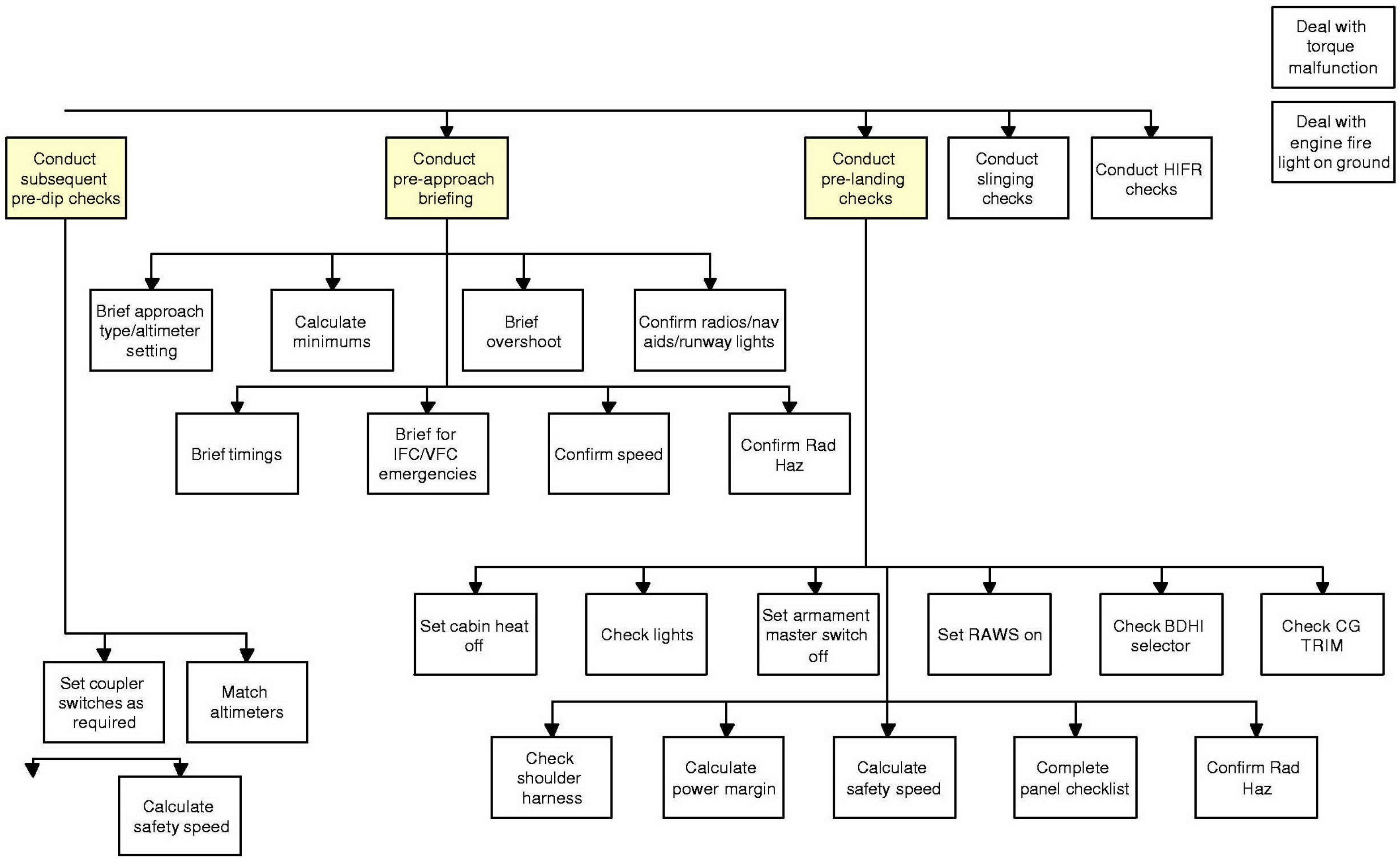


(emergency checks, not to be modelled) Continued on next page



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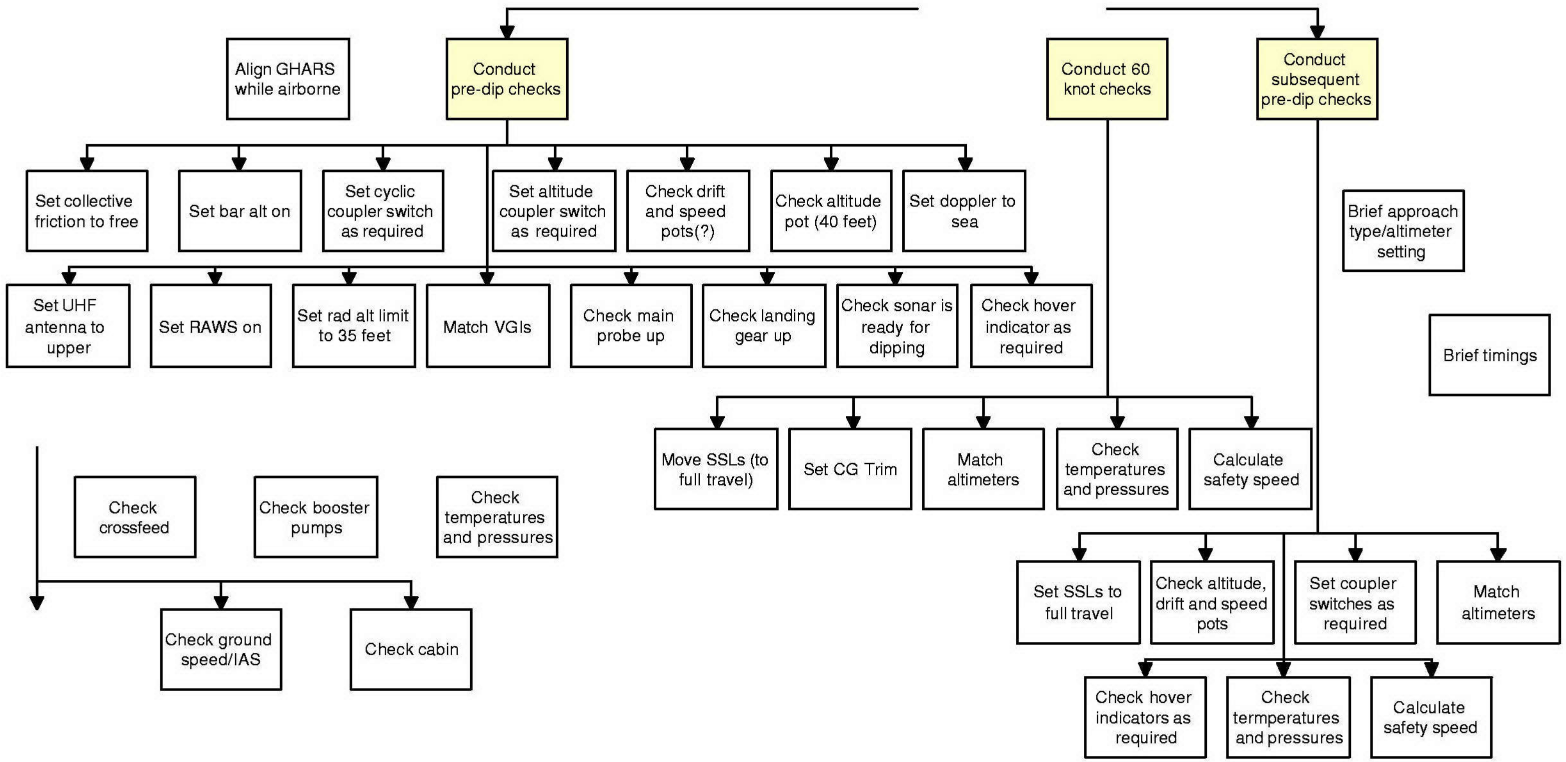

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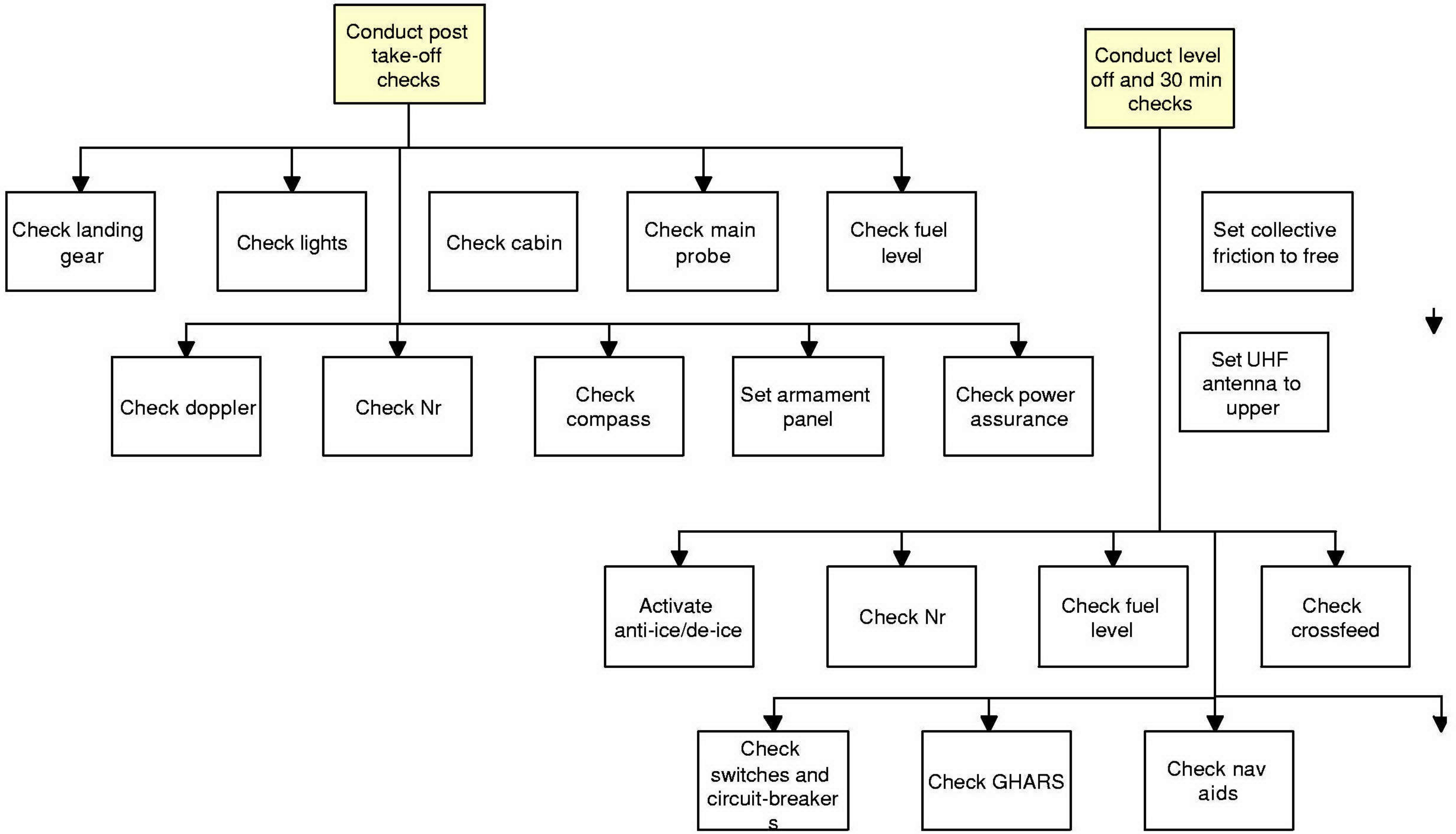

Conduct post take-off checks
Check landing gear
Check lights
Check cabin
Check main probe
Check fuel level
Check doppler
Check Nr
Check compass
Set armament panel
Check power assurance
Conduct level off and 30 min checks
Set collective friction to free
Set UHF antenna to upper
Activate anti-ice/de-ice
Check Nr
Check fuel level
Check crossfeed
Check switches and circuit-breaker s
Check GHARS
Check nav aids

Annex B:
Helicopter Deck Landing Mission

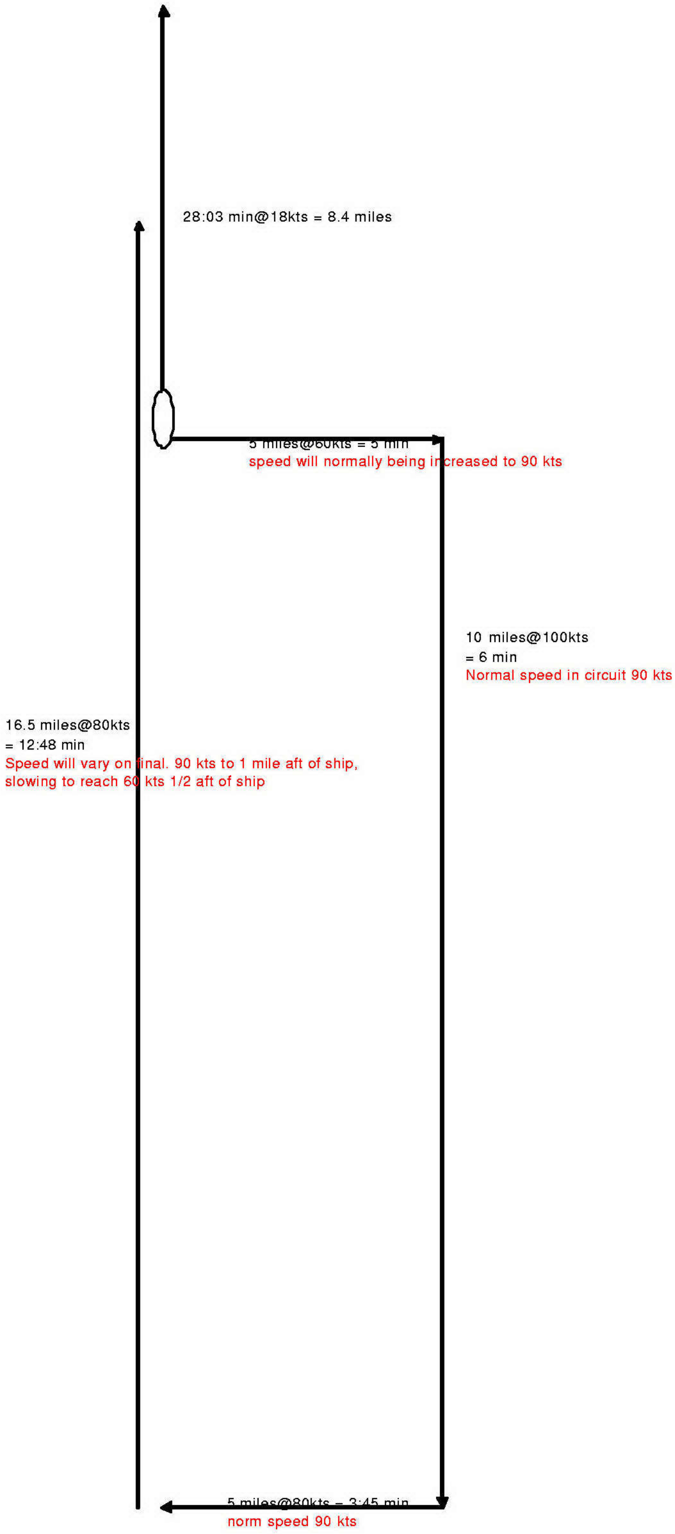
Time	Helo Position	Ship Position	Goal A	Goal B	Goal C	Goal D	Goal E	Goal F	Trigger	Description of Event	Comments/ Questions
Continuous	all	all	Conduct instrument scan	Determine expected value/ status	Compare observations with expectations	Adjust flight controls to achieve expectations.			If it, or an activity that involves it, hasn't been done for 90 seconds; can be deferred until another ongoing task is completed	Typical "T-Scan" of instruments. With Attitude indicator being main focus of attention. Depending on flight regime other instruments will become more or less important (eg: Radar Altimeter very important below 100'AGL not so above 100'AGL)	We need to know what values to assign to instruments; is it a value or a position? Also, where Goal A - F is filled in, this represents a sequence of goals, where one is initiated by the end of another.
Continuous	all	all	Receive trigger stimulus	Determine which goal(s) is/are activated	Determine relative priority of goals	Determine whether parallel goal(s) achievement possible	Pursue goal			Be alert for radio, intercomm, equipment indicators, external visual signals, psychophysical indicators. Follow tasking instructions and/or procedures	Listing of trigger stimuli and associated goals in other spreadsheet
Continuous	all	all	Manage workload	Determine relative priority of goals	Determine whether parallel goal(s) achievement possible	Pursue goal					Workload management is a byproduct of other activities.
Continuous	all	all	Conduct external scan	Determine expected value/status	Compare observations with expectations	Adjust flight controls to achieve expectations				This may involve comm either internal or external in order to achieve the expectation	Maintain SA is a byproduct of other activities

Time	Helo Position	Ship Position	Goal A	Goal B	Goal C	Goal D	Goal E	Goal F	Trigger	Description of Event	Comments/ Questions
Continuous 0:00:00	O	O	Operate cyclic	Operate collective	Operate pedals						To maintain desired heading, altitude and speed.
	O O O	O O O	Conduct pre-take-off checks	Conduct crew cross checks	Operate interphone system	Acknowledge comms			Launch - 1 min		If the engine is already running, lashings gone, intercomm cable disconnected, would pre-take-off checks be done then, or earlier?
	O	O	Attend to external visual signals	Determine which goal(s) is/are activated	Determine relative priority of goals	Determine whether parallel goal(s) achievement possible	Pursue goal	Operate UHF tx/rx	Observe trafficator lights turn green		Is there an R/T call to say the helo can take off?
	O	O	Receive instructions	Operate tail probe	Receive instructions	Attend to external visual signals			Observe trafficator lights turn green	Raise tail probe	Is this done here, or has it already been done?
0:00:01			Operate cyclic	Operate pedals	Operate collective	Attend to external visual signals			After tail probe has been raised	Vertical takeoff to hover	Hover 30'.
			Operate cyclic	Operate pedals	Operate collective	Attend to external visual signals				Maintain position over ship	
			Operate cyclic	Operate pedals	Operate collective	Receive instructions				Maintain position over ship	
	Abeam ship after T/O		Operate cyclic	Operate pedals	Operate collective					Sideward hovering flight	Off the side of the ship

Time	Helo Position	Ship Position	Goal A	Goal B	Goal C	Goal D	Goal E	Goal F	Trigger	Description of Event	Comments/ Questions
	Trans to forward flight Accelerating		Operate landing gear	Operate cyclic	Operate pedals	Operate collective				Accelerate to 90 kts straight ahead; THEN climb to 200 - 300' at 500 fpm	
			Operate cyclic	Operate pedals	Operate collective				position	Forward turn, like an aeroplane.	To 90 deg
			Conduct post take-off checks	Pilot will pass radio comm responsibility to Nav at this point who will contact the SAC in order to receive firther instructions.	Operate interphone system				Once established on track, in climb		Done immediately after leaving the ship
	Level, commencing X-wind turn		Conduct level off and 30 min checks						Once level at 200 - 300'		Is this when level or at 30 min - if at 30 min, then we won't have to do it.
			Receive instructions						R/T: Transfer to SAC fx		As the helo passes the bow of ship.
	In circuit on X-wind leg										
0:05:30	O+5@90/1000 Downwind leg	O+1.5@000	Operate cyclic appropriately	Operate pedals	Operate collective				At position	Turn right 90 deg like an aeroplane	

Time	Helo Position	Ship Position	Goal A	Goal B	Goal C	Goal D	Goal E	Goal F	Trigger	Description of Event	Comments/ Questions
0:11:30	O+11.36 @135/1000 Turning Base	O+3.45 @000	Operate cyclic	Operate pedals	Operate collective				At position	Turn right 90 deg	
			Conduct pre-approach briefing	Operate interphone system					Trigger will be driven by SOPs	After descent has been initiated (i.e. in descent)	
			Conduct pre-landing checks	Conduct crew crosschecks	Operate interphone system	Acknowledge comms					
0:15:15	O+10@180/1000	O+4.575 @000	Operate cyclic	Operate pedals	Operate collective				At position	Turn right 90 deg	
	Final		Operate cyclic						Subsequent to above	Maintain 90 kts to 1mile behind ship.	
	Descending and decelerating (200' & 60 kts)		Operate cyclic	Operate pedals	Operate collective				Subsequent to above	Descend to 200 (normal climb and descent goal) and decelerate to 60 kts by 1/2 mile behind ship	
			Attend to radio comms	Receive instructions					R/T: Transfer to LSO fx		
			Acknowledge comms	Operate UHF tx/rx					R/T: Roger		
			Initiate comms	Operate UHF tx/rx					R/T: Check in on LSO fx	Add position report	
			Attend to radio comms						R/T: Roger c/s		
0:28:03	O+6.5@180/200	O+8.4@000	Operate cyclic	Operate pedals	Operate collective	Operate landing gear			Abeam ship just prior to moving sideways over deck	Move forward to abeam helicopter deck; lower landing gear	During hover - this may already be implied - but pilot will be constantly operating cyclic, collective,

Time	Helo Position	Ship Position	Goal A	Goal B	Goal C	Goal D	Goal E	Goal F	Trigger	Description of Event	Comments/ Questions
											and pedals in order to maintain a steady hover.
			Operate cyclic	Operate pedals	Operate collective					Sideward hovering flight to above heli deck	
			Receive instructions	Operate messenger					In stable hover over flight deck. On command from LSO.	Lower messenger	
			Receive instructions						R/T: Stop lowering messenger		
			Operate messenger							Stop lowering messenger	
			Receive instructions						R/T: Raise messenger		
			Operate messenger							Raise messenger	
			Attend to equipment indicators							Three greens	
			Initiate comms	Operate UHF tx/rx						Call for hover tension	
			Receive instructions						LSO: land now, down, down, down		
			Operate cyclic	Operate pedals	Operate collective					Normal climb & descent for landing at sea - 8 ft/sec or 480 ft/min	
			Operate cyclic	Operate pedals	Operate collective					Setdown	Collective will be at full down position
			Receive instructions							Lower tail probe	
			Operate tail probe							Lower tail probe	


28:03 min@18kts = 8.4 miles
5 miles@60kts = 5 min
speed will normally being increased to 90 kts
10 miles@100kts
= 6 min
Normal speed in circuit 90 kts
16.5 miles@80kts
= 12:48 min
Speed will vary on final. 90 kts to 1 mile aft of ship,
slowing to reach 60 kts 1/2 aft of ship
5 miles@80kts = 3:45 min
norm speed 90 kts

Annex C:
IPME Data

Due to the size of the IPME data file (approximately 60 pages), the Excel file is hyperlinked. To view the file, please click here:

Helo IPME Data - GDW comments.2.xls

Annex D:
Preliminary Catalogue of Stimuli and Goals

Communication	From	To	Result of (goal)	Triggering (goal)
Met report	Tofino Coast Guard	Broadcast		
Loose advisory control	SAC	Stinger 36		
MHCC expectations	Pilot	Copilot		
Affirm	Copilot	Pilot		
Complete prelanding checklist	Pilot	Copilot		
Checklist items	Copilot	Pilot		
Safe single engine speed 34 kts	Copilot	Pilot		
Visual with ship	Pilot	Crew		
Visual with ship	TACCO	SAC		
Acknowledge visual and numbers: flying course 360 at 5, true wind 303 at 17, relative wind red 45 at 22, altimeter 3000	SAC	TACCO		
Roger	TACCO	SAC		
Request permission for recovery (via lights)	LSO	Bridge		
No light on request panel	Bridge	LSO		
Transfer to L/L fx	SAC	TACCO		
Transfer to L/L fx	TACCO	Copilot		
New fx	Copilot	TACCO		
Regina, this is Stinger 36 over	TACCO	SAC		
Roger, ship closed up at flying stations, radhaz safe, cleared to close, *call when visual*	SAC	TACCO		
Acknowledged	TACCO	SAC		
Visual with helo, happy to take control	LSO	SAC		
Acknowledged	SAC	LSO		
Call paddles for control	SAC	TACCO		
Your radios	TACCO	Copilot		
Roger my radios	Copilot	TACCO		
Roger	Copilot	SAC		
Break, paddles stinger 36 calling for control	Copilot	LSO		
Stinger 36 this is paddles over	LSO	Copilot		
Paddles 36 roger out	Copilot	LSO		
<u>Select two mile lighting</u>	<u>LSO</u>	<u>FLYCO</u>		
Come round to flying course	OOW	Helm		
Signal delta hover astern	LSO	Copilot		
<u>Signal Delta</u>	<u>LSO</u>	<u>Copilot</u>		
Trafficator lights to amber	FLYCO	Pilot		
Trafficator lights to red	FLYCO	Pilot		
Acknowledge	Copilot	LSO		
Complete panel checklist	Pilot	Copilot		
Checklist items	Copilot	Pilot		
Set sonar	Copilot	AESOP		
Seated and sighted	AESOP	Copilot		

Communication	From	To	Result of (goal)	Triggering (goal)
Panel check complete, landing gear to go	Copilot	Pilot		
Acknowledge	Pilot	Copilot		
<u>Turn downwind</u>	<u>MHCC</u>	<u>Pilot</u>		
Safe single	Copilot	Pilot		
Call the deck motion	*Pilot*	*LSO*		
Reply	*LSO*	*Pilot*		
Permission to recover	OOW	Captain		
Authorised	Captain	OOW		
Yes light on request panel	OOW	LSO		
Numbers remain the same	OOW	LSO		
Acknowledged	LSO	OOW		
Signal charlie freedeck	LSO	Copilot		
Signal charlie hauldown	*LSO*	*Pilot (???)*		
Trafficator lights to green	FLYCO	Pilot		
Acknowledged	Pilot (??)	LSO		
<u>Select one mile lighting</u>	<u>Pilot</u>	<u>MHCC</u>		
<u>Acknowledged</u>	<u>MHCC</u>	<u>Pilot</u>		
<u>Select one mile lighting</u>	<u>MHCC</u>	<u>LSO</u>		
<u>Select one mile lighting</u>	<u>LSO</u>	<u>FLYCO</u>		
I've got a light	Copilot	Pilot		
I've got a light	Pilot	Copilot		
Gear down and locked	Copilot	Pilot		
Lower the messenger	*Pilot*	*Copilot*		
Stop lowering	*LSO*	*Copilot*		
Trafficator lights to amber	FLYCO	Pilot		
Raise the messenger	*LSO*	*copilot*		
Trafficator lights to green	*FLYCO*	*Pilot*		
Three green	*Copilot*	*pilot*		
Three green, hover tension	*Pilot (???)*	*LSO*		
Hover tension	*LSO*	*Pilot (???)*		
Trafficator lights to amber	*FLYCO*	*Pilot*		
Minor conning	Copilot	Pilot		
<u>Heading, altitude and airspeed comments</u>	<u>Pilot</u>	<u>Copilot</u>		
<u>Safe Single</u>	<u>Copilot</u>	<u>Pilot</u>		
<u>I have control</u>	<u>Pilot</u>	<u>Copilot</u>		
<u>You have control</u>	<u>Copilot</u>	<u>Pilot</u>		
<u>Heading, altitude and airspeed comments</u>	<u>Copilot</u>	<u>Pilot</u>		
Ready to land	Pilot (???)	LSO		
Land now, down, down, down	LSO	Copilot (Pilot)		
Wave off, wave off, wave off	LSO	Copilot (Pilot)		
Roger, wave off, wave off, wave off	Pilot (????)	LSO		
Trafficator lights to red	FLYCO	Pilot		
Hooked on, minimum tension	*LSO*	*Pilot*		

Communication	From	To	Result of (goal)	Triggering (goal)
Three green, hover tension	*Pilot (???)*	*LSO*		
Hover tension	*LSO*	*Pilot (???)*		
All clear	LSO	Copilot (Pilot)		
Trafficator lights to amber	FLYCO	Pilot		
Ready to land	Pilot (????)	LSO		
Minor conning	LSO	Copilot (Pilot)		
Land now, down, down, down	LSO	Copilot (Pilot)		
Trafficator lights to green	FLYCO	Pilot		
In the trap, trapped, down tail probe	LSO	Copilot (Pilot)		
Trafficator lights to amber	FLYCO	Pilot		
Tail probe is down	LSO	Copilot (Pilot)		
Off light on recover (request?) panel	LSO	Bridge		
Helo is trapped on deck, clear to manoeuvre with caution	LSO	Bridge		
Release	*LSO*	*Pilot*		
Signal delta hover astern				
Signal charlie freedeck				
Signal charlie hauldown				
Signal charlie cleardeck				
Signal charlie portable bellmouth				
Signal charlie for hoist transfer				
Signal charlie for sling				
Signal charlier for HIFR (hot inflight refuelling)				
Signal charlier for focsle transfer				
Signal delta				
Safe single (engine) speed				
Minor conning commands (directions)				
Lower the messenger				
Raise the messenger				
Altitude				
Airspeed				
Call when visual				
Land now, down, down, down				
Wave off, wave off, wave off				
Call deck motion				
Three greens				
Hover tension				
Minimum tension				
Hooked on				
Constant tension				
Release				

Communication	From	To	Result of (goal)	Triggering (goal)
Lower tail probe				
Request one mile lighting				
Request two mile lighting				
Ship closed up at flying stations				
Radhaz safe				
Cleared to close				
In the trap. Not trapped, landing tension				
Standby release/call your release				
Releasing, now, now, now				
All clear				
Ready to engage				
Cleared to engage, relative wind xxx				
Ready for takeoff, ASE, bar alt, tail probe, lashings, intercom to go, safe single XXkts				
Up tail probe				
Tail probe is up standby				
Cleared take off				
All clear (alternative to this is below)				
Hooked on, minimum tension				
RAdhaz safe				
Radhaz safe port/starboard				
Radhaz safe forward/aft				
Abort, abort, abort				
Left				
Right				
Ahead				
Back				
Up				
Down				
Steady				

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14. ABSTRACT

(U) Defence Research and Development Canada (DRDC) Toronto contracted Humansystems Incorporated® (Humansystems®; HSIâ) to conduct a hierarchical goal analysis and construct a human performance model of pilot activities associated with the Sea King helicopter. In particular, DRDC Toronto wanted the human performance model to include activities surrounding Helicopter Deck Landing (HDL) aboard a Navy ship. Ultimately, this model would be used to control a simulated Sea King helicopter. The human performance modelling application used for this project was the Integrated Performance Modelling Environment (IPME).
This report describes the output from the goal analysis, the mission used to 'bound' the IPME modelling efforts, the data used to populate the IPME model, assumptions and approach used in the modelling effort, conclusions, and recommendations for follow-on work. With respect to the follow-on work, some suggestions are made regarding areas to focus on and approach to take. The IPME model of Sea King helicopter pilots forms a separate deliverable under this contract.

(U) Recherche et développement pour la défense Canada (RDDC) Toronto a attribué un contrat à Humansystems Incorporated (HSI) pour effectuer une analyse hiérarchique d'objectifs et construire un modèle de performance humaine pour les activités des pilotes liées à l'hélicoptère Sea King. Plus particulièrement, RDDC Toronto voulait que le modèle de performance humaine comprenne les activités entourant l'atterrissage sur une héliplate?forme à bord d'un navire de la Marine. En bout de ligne, ce modèle servirait à contrôler un hélicoptère Sea King simulé. L'application de modélisation de la performance humaine utilisée pour ce projet était l'environnement intégré de modélisation de la performance (IPME).
Le présent rapport décrit le résultat de l'analyse d'objectifs, la mission utilisée pour « limiter » le travail de modélisation de l'IPME, les données ayant servi à charger le modèle de l'IPME, les hypothèses et la démarche utilisées dans le travail de modélisation, les conclusions et les recommandations pour le suivi. Relativement à ce dernier, des suggestions ont été formulées sur les domaines d'intervention et l'approche à adopter. Le modèle d'IPME pour les pilotes d'hélicoptère Sea King constitue un produit livrable distinct en vertu du présent contrat.

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) human behaviour representation; human modelling; helicopter; Sea King; Integrated Performance Modelling Environment; IPME